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MANURIAL INVESTIGATIONS WITH BANANA (MARTAMAN VARIETY) IN WEST BENGAL

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(Received for publication on February 16, 1956)
(With two Text-figures)

BANANA is an important fruit crop in the State of West Bengal, and is grown extensively in the districts of Hooghly and 24-Parganas, which together account for nearly 19,500 acres. It is a common practice with the banana growers to maintain plantations, particularly of the Champa variety, over long periods, sometimes even for four to five decades, without renewal. The banana is widely recognised to be a gross feeder ; consequently, it is of paramount importance to maintain a high degree of soil fertility, if the production is to be continued on an economic level over long periods. The present investigations were undertaken to form a preliminary idea of the fertiliser requirements of banana under the local conditions.

In Trinidad, Wood [1932] obtained increased yield with the application of farmyard manure and potash in a fertiliser experiment on Cavendish banana. In view of the difficulties involved in carrying out systematic fertiliser trials in Canary Islands, Baillon *et al.*, [1933] estimated the nutrient requirements of Cavendish banana by analysing a mature plant as roughly 6 oz. of nitrogen, 1·2 oz. of phosphate, and 27·5 oz. of potash. Accordingly, they recommended a fertiliser mixture moderate in nitrogen, low in phosphorous and high in potash. Croucher and Mitchel [1940] have reported results of fertiliser investigations carried out with Gros Michel banana at four main centres in Jamaica. They have mentioned about the United Fruit Co. of the United States of America having conducted a series of manurial trials in the soils rich in available potash and phosphorous in Jamaica, in which response to the application of nitrogen alone was obtained. In their own experiments, however, they found the application of both potash and phosphorous effective. Phosphorous appeared to stimulate growth but excess of it had depressing effect on the number, weight and size of fingers, which was, however, counteracted by liberal supplies of potash. The application of potash improved the quality of fruit particularly the length and weight of the fingers. Maturity was reduced by about two months by the application of nitrogen ; the addition of phosphorous and potash to the soils deficient in these elements caused considerable reduction in the growth period.

They have formulated a table for sedentry banana soils in Jamaica showing the probability of obtaining response to the application of phosphatic and potassic fertilisers to soils with available P_2O_5 and K_2O to the extent of 10 p.p.m. and 250 p.p.m. respectively, and accordingly suggested six-monthly applications

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of 8 oz. of sulphate of potash and 1 lb. of superphosphate (18 per cent) each time, depending upon their availability in soils, to a basic annual dose of 1 lb. and 8 oz. of ammonium sulphate per stool.

Bowman and Eastwood [1940] obtained 2 per cent increase in yield in an experiment conducted over five years in Jamaica with the application of 3 lb. of sulphate of potash per stool ; 2 oz. of sodium nitrate increased production by 30 per cent, whereas phosphorous did not show any appreciable response. Stephens [1945] states about fertiliser experiments having been conducted at Buderim, Australia. The importance of high potash content in the fertiliser mixture is emphasised ; mixtures with 1 : 1 : 2 or 1 : 2 : 4 N P K ratios at the rate of one ton per acre are recommended. While reviewing the banana industry in Australia, Richards [1951] describes heavy applications of 10 : 8 : 10 N P K fertiliser mixture in three doses at the rate of 2 lb. per stool ; some growers apply 8 lb. of dried blood and bone manure in addition to 1 lb. of ammonium sulphate per stool annually.

Dhareshwar [1952] recorded higher yield and income by applying 80 lb. of farmyard manure (equivalent to 0·4 lb. N) than that in the case of 80 lb. of farmyard manure and 2 lb. of ammonium sulphate (equivalent to 0·8 lb. N) per stool in a fertiliser trial with *Basrai Dwarf* at the Ganeshkhind Fruit Experimental Station, Kirkee, India. He, however, does not explain for the reduction in yield with doubling the dose of nitrogen. Borel [1952] secured the highest yield in a fertiliser experiment with Gros Michel in French Cameroons with the application of 1 : 5 : 2 N P K mixture at the rate of 500 kg. each of sulphate of ammonia and dicalcium phosphate and 1100 kg. of sulphate of potash per hectare. Pelegrin [1953] found the fertiliser requirements of Musa sinensis to be 4-5 tons in French Guinea ; of Poyo, 3 tons in Guadeloupe ; and of Gros Michel, 2 tons per hectare in French Cameroons. He recommended a 6 : 7 : 28 N P K fertiliser mixture, the potash requirements being 3-5 times that of nitrogen.

Nayar [1953] obtained the maximum yield by applying 8 oz. of nitrogen per stool, half from cattle manure and the balance from sulphate of ammonia over a basic dose of 25 lb. of cattle manure in a manurial experiment with the Poovan variety. The yield was, however, lower when the same quantity of nitrogen was applied in the form of 4 oz. of nitrogen each from cattle manure and groundnut cake, or ammonium sulphate and groundnut cake.

In West Bengal it is a common practice to intercrop banana during the first year of its planting with eggplant which is manured with 100 to 150 maunds of cowdung and 5 to 6 maunds of mustard oilcake per acre, the manure being partly consumed by the banana plants. Subsequently, cowdung and tank silt which, as an average of a 8 silt samples from West Bengal analysed by Sen and Asija [1954], has a chemical composition of : total N 0·24 per cent, P_2O_5 0·23 per cent, and K_2O 0·93 per cent on oven-dry basis, are applied at the rate of one and 2-3 baskets, weighing 15-20 seers each, per stool respectively annually in the beginning of rains, supplying altogether about 4 oz. of nitrogen. Where cowdung is not available tank silt alone is applied ; some keen growers, however, also apply 2-3 lb. of mustard oilcake per stool, which adds roughly another 2 oz. of nitrogen.

Material and Methods

The experiment was conducted in a well-drained loamy, alluvial soil at Krishnagar. The chemical analysis of the soil before commencement of the experiment is given in Table I.

Table I

Soil analysis

Depth	Moisture per cent	Nitrogen per cent	Available P_2O_5 per cent	Available K_2O per cent
0-6 in.	2·38	0·0742	0·0061	0·006
6-12 in.	3·52	0·061	0·0068	0·004
12-18 in.	3·968	0·0693	0·0091	0·0037

N.B.—Result expressed on air-dry basis.

Martaman, a commercial variety of the State, was selected for the experiment. Uniform suckers of approximately the same age and size were planted 10 ft. apart on all sides on the 14th July, 1951.

The treatments were as follows :

A. Control : no manure ;

B. 4 oz. of N from cowdung ;

C. 4 oz. of N from cowdung and 4 oz. of N from ammonium sulphate ;

D. 4 oz. of N from mustard cake and 4 oz. of N from ammonium sulphate

E. 4 oz. of N from cowdung and 4 oz. of N from mustard cake ;

F. 4 oz. of N from cowdung and 8 oz. of P_2O_5 from superphosphate ;

G. 4 oz. of N from cowdung and 8 oz. of K_2O from sulphate of potash ;

H. 4 oz. of N from cowdung and 8 oz. of P_2O_5 from superphosphate and 8 oz. of K_2O from sulphate of potash per stool.

The layout followed was randomised blocks with four replications. Each sub-plot was 30 ft. × 30 ft. accommodating 9 experimental plants and provided with a guard row of the same variety all round. A 1½-ft. deep drain was provided in between the sub-plots to prevent leaching of nutrients from one treatment to another.

The scheduled quantity of manure was applied in two equal doses ; the first dose was applied on the 3rd August, 1951, and the second dose on the 20th October 1951 ; subsequently, the first and second doses were applied in July and October respectively each year. The manures were distributed evenly in a ring 3 ft. wide around the plants and hoed in 2-3 in. deep. The cultural and desuckering operations were attended to regularly in the usual manner.

The experiment was continued till June, 1954, during which period the plant and one ratoon crop were obtained, but a severe attack of Panama disease necessitated its abandonment. The distribution of rainfall during the relevant period is given in Table II.

TABLE II

Maximum and minimum temperatures, rainfall, and number of rainy days

Month	Maximum temperature (°F)	Minimum temperature (°F)	Rainfall in inches	No. of rainy days
		1951		
July	94	76	12·59	21
August	94	74	8·7	23
September	96	64	5·51	10
October	95	75	9·05	10
November	92	56	1·67	2
December	88	50	*nil*	*nil*
		1952		
January	90	45	*nil*	*nil*
February	96	50	0·32	2
March	105	55	1·63	6
April	106	68	3·42	7
May	100	70	2·92	11
June	102	74	13·16	17
July	94	76	9·79	23
August	92	78	4·66	17
September	99	78	8·79	14
October	98	60	6·49	6
November	90	50	0·5	1
December	90	45	*nil*	*nil*
		1953		
January	86	40	0·39	2
February	96	50	0·85	1
March	106	55	1·64	2
April	110	72	1·84	3
May	106	76	3·52	8
June	102	76	11·9	15
July	96	78	21·33	20

Growth data of height and girth were recorded two months after planting and continued bi-monthly till flowering. Height measurements to the nearest inch from the ground level, which was determined from wooden pegs fixed in each row to avoid errors in recordings due to soil disturbances, to the junction of the petioles of the two youngest leaves were taken.

RESULTS

(a) *Growth*

Response to the application of nitrogen in the growth of plants became apparent in the observations made two months after the planting. The height and girth measurements recorded bi-monthly are summarised in Tables III and IV respectively.

It is interesting to note that development of the plants in height followed almost the same trend as that in girth throughout the growing period. By September, 1951, treatment C (ammonium sulphate plus cowdung) gave superior height and girth measurements than treatments E and D (cowdung plus mustard cake, and ammonium sulphate plus mustard cake), supplying the same quantity of nitrogen. However, the difference in growth between C and E treatments persisted till January, 1952, thereafter becoming non-significant among C, D and E, i.e. the treatments with 8 oz. of nitrogen per stool in different combinations. The application of cowdung alone in treatment B did not show significant effect on height until January, 1952, and on girth until November, 1951, obviously due to slow availability of organic nitrogen.

The effect of the application of phosphorous to a basal dose of 4 oz. of nitrogen per stool in treatment F was noticeable on height and girth in January, 1952, and on girth alone in May 1952. Potash, similar to phosphorous, responded in growth in treatment G in January, 1952, but in combination with phosphorous in treatment H the effect was more pronounced and was visible on height even in November, 1951. However, the response in growth to the application of phosphorous and potash, alone or combined, was temporary and ultimately became non-significant. It is rather noteworthy that treatments C, D and E gave superior growth than F, G and H throughout the period of growth except in September, 1951.

The mean growth in different treatments provides an interesting study. It is apparent from Figs. 1 and 2 that the over-all mean growth among the treatment with 8 oz. of nitrogen was the highest in D, closely followed by E and C ; and during the first six months after planting the quickest to grow in the descending order were D, C and E. It appears that the treatment C had the initial advantage of quick growth, followed by a uniform rate ; D made rapid growth as soon as the nitrogen from mustard oil cake augmented the supply from ammonium sulphate ; and E maintained a moderate but uniform growth.

In the treatments F, G and H growth was slow and more or less uniform till March, 1952, when with the receipt of rainfall and warm weather (Table II) the growth, as in other treatments, became rapid. During the period from December, 1951, to February, 1952, when the temperature, and soil moisture in the absence of rainfall were low the growth was generally poor, particularly in the treatments A and B with no-manure and 4 oz. of nitrogen respectively. Growth is thus closely associated with temperature and soil moisture, which considerably influence the nutrient supply to plants.

(b) *Maturity*

While assessing the return from a crop, maturity or, in other words, the duration for which it occupies the land, needs equally important consideration along with other factors such as yield and quality of the produce. A study of the data given in Table V shows that fertilisation exercises marked influence on maturity in banana.

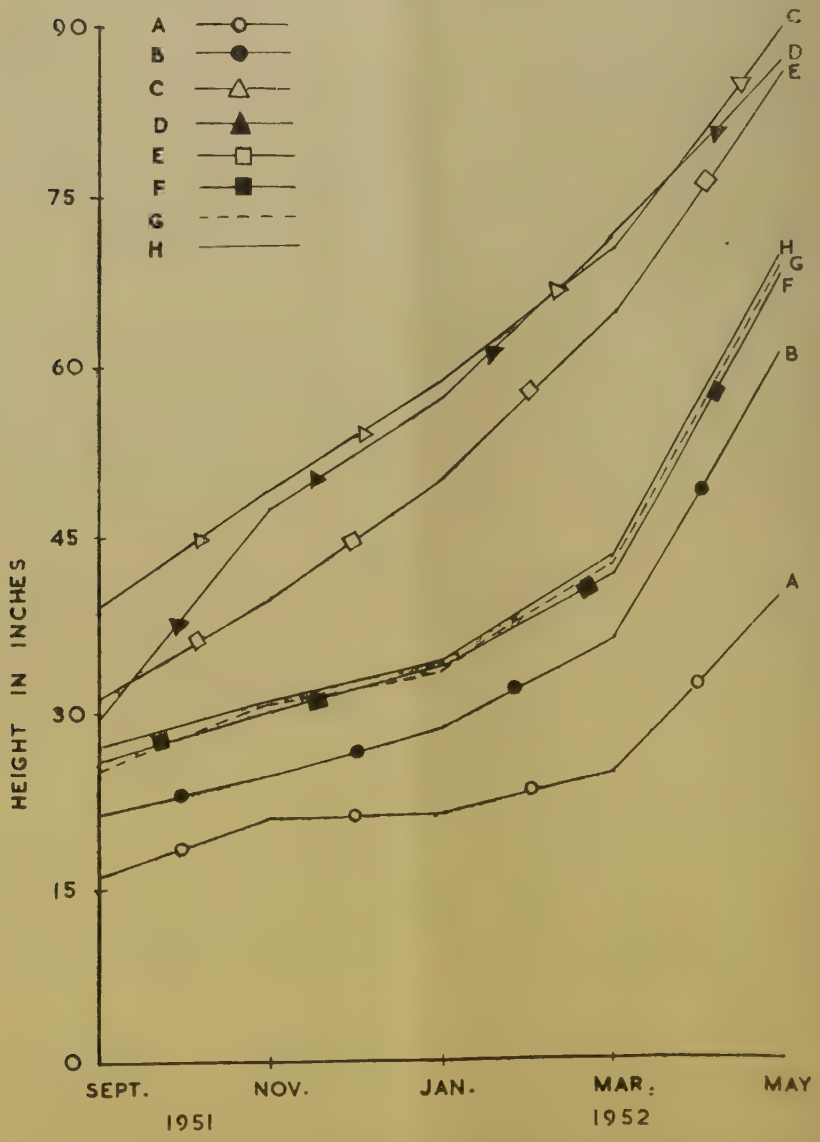

Fig. 1. Effect of manurial treatments on growth ; A. Height.

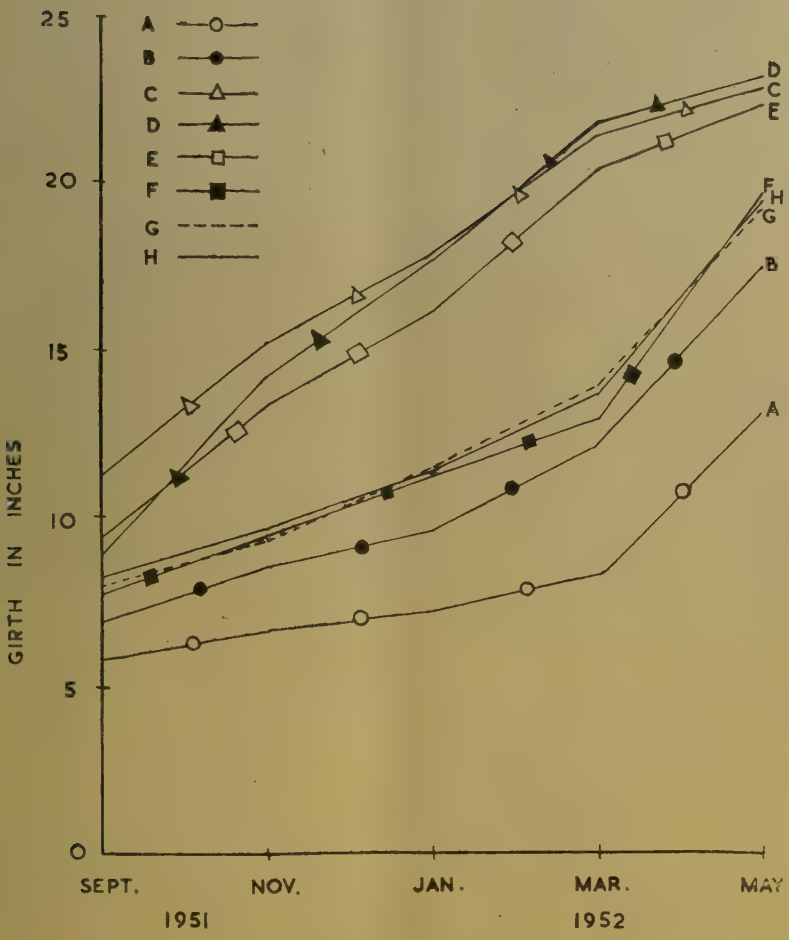

FIG. 2. Effect of manurial treatments on growth ; B. Girth.

TABLE III

Height measurements (inches)

Date	Treatments								S. E. of mean difference	Critical difference P = 0·05	Remarks
	A	B	C	D	E	F	G	H			
					1951						
September	16·15	21·47	39·10	29·97	31·45	26·20	25·42	27·40	3·25	6·76	C E D H F G B A
November	21·02	24·77	49·42	47·87	41·50	30·15	30·52	30·82	2·85	5·92	C D E H G F B A
					1952						
January	21·90	28·97	58·22	57·45	50·32	34·30	34·20	34·50	2·49	5·17	C D E H F G B A
March	25·05	36·27	70·42	70·92	64·80	42·40	42·85	43·52	3·50	7·28	D C E H G F B A
May	40·22	61·42	89·82	86·82	86·25	68·07	68·90	69·95	4·24	8·81	C D E H G F B A

TABLE IV

Girth measurements (inches)

Date	Treatments								S. E. of mean difference	Critical difference P = 0·0 5	Remarks
	A	B	C	D	E	F	G	H			
					1951						
September	5·82	6·92	11·17	8·92	9·45	7·75	7·95	8·17	0·64	1·33	C E D H G F B A
November	6·62	8·50	15·15	14·37	13·35	9·50	9·32	9·60	0·60	1·24	C D E H F G B A
				19	*1952*						
January	7·27	9·60	17·77	17·67	16·07	11·30	11·35	11·32	0·68	1·41	C D E G H F B A
March	8·42	12·07	21·45	21·60	20·30	12·95	13·90	13·72	0·93	1·93	D C E G H F B
May	13·10	17·47	22·92	23·02	22·27	19·55	19·45	19·47	0·99	2·07	D C E F H G B A

TABLE V

Maturity (number of days from planting till harvest)

Mean	Treatments								S. E. of mean difference	Critical difference P = 0·05	Remarks
	A	B	C	D	E	F	G	H			
Life in days	866	658	402	408	407	634	628	627	32·10	66·76	A $\overline{\text{BFGH}}$ $\overline{\text{DHC}}$

TABLE VI

Yield

Mean yield	Treatments								S. E. of mean difference	Critical difference P = 0·05	Remarks
	A	B	C	D	E	F	G	H			
					Plant crop						
(*i*) Yield per plant (in lb.)	8·35	12·82	17·22	17·95	16·85	13·02	13·05	12·67	1·18	2·45	$\overline{\text{DCE}}$ $\overline{\text{HGFB}}$ A
(*ii*) Yield per acre (in tons)	1·623	2·492	3·347	3·489	3·275	2·531	2·536	2·657			
					Ratoon crop						
Yield per plant (in lb.)	13·02	21·60	30·25	30·75	29·47	22·42	21·62	23·05	1·22	2·53	$\overline{\text{DCE}}$ $\overline{\text{HFGB}}$ A
Yield per plant (in tons)	2·531	4·199	5·880	5·977	5·728	4·358	4·202	4·480			

Duration of the crop in the treatments C, D and E (8 oz. of nitrogen per stool in different combinations) was the shortest of all the treatments ; there was, however, no significant difference within them. In the case of no-manure in treatment A, the duration was the longest and more than double that of the treatments C, D and E with 8 oz. of nitrogen. The addition of 8 oz. each of phosphorus (P_2O_5) and potash (K_2O), individually or combined, to a basal dose of 4 oz. of nitrogen in the treatments F, G and H did not show any significant effect on maturity.

(c) *Yield*

Harvesting of the plant crop was commenced in July, 1952, and completed by March, 1954 ; the harvesting period in the case of ratoon crop extended from May, 1953, to June, 1954. The yield data of the plant and ratoon crops are summarised in Table VI. The bunch weight, as expected, followed the same trend as that in growth. It is apparent that the treatments, which gave the maximum height and girth measurements and the highest rate of growth, produced, in general, the heaviest bunch weight.

The application of 8 oz. of nitrogen in different combinations in the treatments C, D and E produced significantly higher average yield per plant, as well as per acre, than that of 4 oz. of nitrogen, alone or in combination with 8 oz. each of phosphorus (P_2O_5) and potash (K_2O) per plant. There was, however, no significant difference in yield among the treatments C, D and E, receiving 8 oz. of nitrogen each in different combinations. The application of phosphorus and potash, alone or combined, to a basal dose of 4 oz. of nitrogen per stool did not result in any significant increase in yield. In the control sub-plots yield was markedly low.

The trend of yield in the ratoon crop was similiar to that in the plant crop. It is noteworthy that yield of the ratoon crop was appreciably higher than that of the plant crop in all the treatments.

(d) *Hands and fingers*

Apart from the bunch weight, the number of hands and fingers in a bunch, colour and appearance of the fruit, and stage of maturity are taken into consideration in determining the market value of the banana fruit. Bunch weight is an indication of the size and development of the fingers ; the number of fingers in a bunch, which is expressed in terms of *pon* (equivalent to 80 in number) in the local wholesale trade, features high in assessing the price.

The application of 4 oz. of nitrogen per stool in the treatment B increased the number of hands and fingers per bunch ; their number was further increased at the higher level of nitrogen in the treatments C, D and E. In the treatment F phosphorus, applied to a basal dose of 4 oz. of nitrogen, did not produce any significant effect on the number of hands and fingers per bunch. Similarly, potash did not show significant response, though apparently it seemed to improve their number ; however, the application of potash, alone and in combination with phosphorus in the treatments G and H respectively, to a basal dose of 4 oz. of nitrogen increased the number of fingers per bunch up to the level of the treatment E, i.e. 8 oz. of nitrogen from cowdung and mustard cake.

Discussion

Response to the application of nitrogen, as expected, was obtained in growth, maturity, yield, and grade of the fruit, ie. the number of hands per bunch ; i.e. the effect of nitrogen at the higher level was more pronounced. Superior growth was recorded in the initial stage with the application of ammonium sulphate and cowdung in the treatment C to that with ammonium sulphate and mustard cake, and mustard cake and cowdung in the treatments D and E respectively, at the same level of nitrogen. The difference in growth between the treatments C and E persisted longer, though becoming non-significant subsequently, which was probably due to the slower availability of organic nitrogen than that of mineral nitrogen.

The application of nitrogen resulted in an increased number of hands and fingers per bunch, on which depended the market value of the fruit. The number of hands per bunch, which depends to a large measure on the vigour of the plant, are probably differentiated during early stage of growth [Croucher and Mitchel, 1940]. The higher number of hands per bunch in the treatments C, D and E (8 oz. of nitrogen) as compared with the rest may thus be attributed to superior growth in the early stage. Similarly, the number of fingers per bunch in the treatments with 8 oz. of nitrogen was higher than that with 4 oz. of nitrogen and no-manure. However, potash, alone and in combination with phosphorous, applied to a basal dose of 4 oz. of nitrogen in the treatments G and H respectively, increased the number of fingers upto the level of the treatment E, i.e., 8 oz. of nitrogen from cowdung and mustard cake. The effect of superior growth in the initial stage thus appears to be more marked on the number of hands than fingers in a bunch. It may, therefore, be concluded that it is not only the level of nitrogen but also the rate and period of its availability to the plant which is of significance in determining the grade of fruit in banana.

The influence of nitrogen on yield and maturity was marked. The application of 8 oz. of nitrogen per stool in the treatments C, D and E produced higher average yield per plant, as well as per acre, and resulted in earlier maturity by over 8 months than that with 4 oz. of nitrogen in the treatment B and in less than half the period as compared to that without manure. No significant difference in yield and maturity was, however, observed among the treatments C, D and E, supplying 8 oz. of nitrogen each per stool in different combinations. These results broadly agree with the findings of Croucher and Mitchel [1940] and Nayar [1953]. It thus follows that optimum results can be obtained from the plants which put on maximum vegetative growth and fruit in the shortest period. There appears to be a positive correlation between the growth and the yield and negative correlation between the maturity and the yield. The plant should grow rapidly from the early stage to produce high yield with superior grade of the fruit.

Response to the application of phosphorous was limited in growth and absent in maturity and yield ; its effect on growth was, however, noticeable when applied in combination with potash in November, 1951, and January, 1952. Phosphorous applied to a basal dose of 4 oz. of nitrogen in the treatment F did not affect the number of hands and fingers per bunch.

The availability of phosphorous in soils to plants is a complicated problem. While experimenting with maize in sand culture, Glover [1953] concluded that for the efficient growth of plants nutrient balance between nitrogen and phosphorous was essential. He further suggested that if nitrogen was the limiting factor in growth, addition of phosphorous in excess of that required to balance the nitrogen supply was not likely to show response, and *vice versa*. The result of the present investigations indicate that the restricting factor in growth has been nitrogen, not phosphorous. Poor response of phosphorous might then have been due partly to the low level of nitrogen at which it was applied. It thus appears that the amount of available phosphorous in the soil is adequate to have balanced growth at the 4 oz.-nitrogen-level, and hence poor response to the applied phosphorous ; also, possibly, the phosphatic requirements of the banana are low. If, however, nitrogenous fertilisation is to become a wide practice and retain its effectiveness, availability of adequate phosphorous to the plants should be ensured to maintain a high level of productivity over long periods.

As in the case of phosphorous, poor response to the application of potash was obtained in growth, maturity and yield, which, as evident from the soil analysis, was probably due to adequate supply of available potash. As already stated, potash seems to improve the number of fingers in a bunch. Since the banana plantations are maintained over long periods, potash supply may become depleted in the course of time and may adversely affect the production. However, as stated elsewhere, the local growers apply tank silt annually, which is a fairly rich source of potash, and, accordingly, the possibility of potash deficiency occuring in the perennial plantations is low. This question, however, needs further study.

The form of nitrogen supply for banana needs consideration with a view to make practical recommendations. Ammonium sulphate is a cheap source of nitrogen in a readily available form but the cumulative effect is likely to increase acidity in soil. Organic matter is widely recognised as a stable source of plant nutrients besides regulating their supply to the plant ; its influence on the microbiological activity and physical properties of soil is noteworthy. Pending further investigations, it is suggested that the nitrogen requirements of the local banana plantations, which may be considered as roughly 8 oz., should be met with partly from ammonium sulphate and partly from the organic sources such as cowdung, compost and oil-cakes. The cost per lb. of nitrogen from ammonium sulphate, cowdung and mustard oil cake at the prevailing market rates is approximately Re. 0-12-6, Re. 1-2-0, and Rs. 2-8-0 respectively.

The present investigations have indicated the trend in response to the application of nitrogen, phosphorous and potash to banana. It is suggested that further investigations are necessary to find out the optimum dose of nitrogen, the source and time of application of fertilisers, the availability of phosphorous at different levels of nitrogen, and the response of potash and its effect on keeping quality and chemical composition of the fruit.

Summary

The article deals with a systematic manurial trial on banana, Martaman variety, carried out at Krishnagar in West Bengal from July, 1951, to June, 1954, with a view to form preliminary idea of the fertiliser requirements of the local plantations. The important results of the investigations are as follows :

(1) Response to the application of nitrogen was obtained in growth, maturity, yield and the number of hands and fingers per bunch ; the effects of nitrogen at the 8-oz.-level were more pronounced than at the 4-oz. level.

(2) Ammonium sulphate and cowdung produced better growth than cowdung and mustard oilcake, each treatment supplying 8 oz. of nitrogen per stool, until six months after planting, the difference, however, becoming non-significant subsequently.

(3) Response to the application of 8 oz. each of phosphorous (P_2PO_5) and potash (K_2O), alone or combined, to a basal dose of 4 oz. of nitrogen, in growth was poor and temporary.

(4) Fertilisation was noticed to exercise marked influence on maturity in banana. Duration of the crop in the treatments with 8 oz. of nitrogen was the shortest of all the treatments. Phosphorous and potash did not show any significant effect on maturity.

(5) The treatments with 8 oz. of nitrogen produced highest yield of all the treatments ; there was, however, no significant difference within them. There was lack of response in yield to the application of phosphorous and potash.

(6) Significant effects were produced on the number of hands and fingers with the application of nitrogen. It is not only the level of nitrogen but also the rate and period of availability to the plant which is of significance in determining the grade of fruit in banana.

(7) Phosphorous produced no significant effect on the number of hands and fingers per bunch. However, potash applied to a basal dose of 4 oz. of nitrogen increased the number of fingers up to the level of 8 oz. of nitrogen from cowdung and mustard cake.

(8) The influence of superior growth in the initial stage appears to be more marked on the number of hands than on fingers in a bunch.

Pending further investigations, it is suggested that the nitrogen requirements of the local banana plantations, which may be considered as roughly 8 oz., should be met with partly from ammonium sulphate and partly from organic sources such as cowdung, compost and oilcakes.

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RESPONSE OF WHEAT VARIETIES TO DIFFERENT SOWING DATES AND SEED RATES

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IT is well known that compared to other countries, the yield per acre of wheat in India is low. The average for India is about 660 lb. as compared to 1,713 lb. in Japan and 1,918 lb. in Egypt. Among the factors known to contribute towards increased yield, the variety, time of sowing, and seed rate are important. A suitable variety sown at the optimum time with a proper seed rate will lead to the requisite stand and conditions for proper performance by the crop. This article embodies the results of the experiments conducted at Balwant Rajput College Experimental Farm, Bichpuri, Agra during the wheat seasons of 1948-51, to study the performance of different varieties of wheat at different sowing dates and varying seed rates.

The climate of this region is sub-tropical with extremes of temperature both in winter (minimum temperature 34 °F.) and summer (maximum temperature 116 °F.). The average annual rainfall at the farm is 25 inches, most of which is received from July to September with occasional showers of one to two inches during winter. The soil of the farm is light loam with average fertility and is well drained.

Material and Method

Investigations were started in *rabi* season (October to April) of the year 1948-49 to study the response of two improved varieties of wheat, viz. *Pb. 591* (late) and *C.13* (early) to three methods of sowing, viz. seed drill, placement through a spout to a depth of four inches attached to a plough locally known as *nai*, and behind the plough, and three dates of seeding, viz. 15th October, 30th October, and 14th November. The results of the experiment indicated that the method of seeding was not of any significance and, therefore, was deleted from the experiments in subsequent years. In the year 1949-50 the experiment comprised the treatments, i.e. three varieties (*Local*, *C. 13* and *Pb. 591*), three dates of sowing (15th October, 30th October and 14th November) and three seed rates (30, 40 and 50 seers per acre). In the following year (1950-51), the '*Local*' variety was omitted and the fortnightly interval between sowing dates was split into weekly intervals. Thus there were two varieties, three seed rates and five dates of seeding (15th, 22nd, and 29th October, 5th and 12th November).

The experimental crop of wheat was taken on different but comparable fields of the farm in different years. The field was left fallow during the preceding *kharif* season (July to October) every year. A basal dressing of farmyard manure at the rate of 60 lb. nitrogen per acre was given to the field in the first and the third year of

the experiment while in the second year the same amount of nitrogen (60 lb. N per acre) was applied through ammonium sulphate. The crops were sown without *palewa* (pre-sowing irrigation) but the subsequent demand of the crop for water was met with irrigation.

The design of the experiment was ' single split plot ' with sowing dates as main treatments and three replications. Although this design reduced the precision of information on sowing dates, it was selected to overcome the agricultural operation difficulties.

Results

Grain and straw yields

The average yields of grain and straw for different varieties, sowing dates and seed rates have been given in Tables I, II and III.

Table I

Average yield of grain, and straw for different varieties (in maunds)

Varieties	1948-49		1949-50		1950-51		Average	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
'Local'	..	..	13·60	73·95	..	..	..	..
Pb. 591	13·98	39·12	25·83	75·43	18·65	50·49	19·48	55·01
C.13 .	12·51	37·50	20·66	67·76	14·73	37·62	15·97	47·63
S. E.	0·50	0·75	0·82	1·50	0·8	0·92	..	..
C. D. 5 per cent	not sig.	not sig.	2·39	4·18	1·61	2·37	..	..

One md. is equal to 40 seers or 82·27 lb.

Table I shows that *Pb. 591* has given consistently higher yields of both grain and straw than *C. 13* ; the average increases for the three years worked out to be 22·0 per cent for grain and 15·5 per cent for straw. Statistically the results were non-significant for both grain and straw in the first year but in the subsequent two years they were highly significant. *Pb. 591* also produced significantly greater amount of grain than *'Local'* in the year 1949-50 but the difference between the straw yields of the two varieties was negligible. Thus *Pb. 591* emerges out to be the best variety for Agra conditions.

TABLE II

Grain and straw yields under different sowing dates (in md. per acre)

Dates	1948-49		1949-50		1950-51	
	Grain	Straw	Grain	Straw	Grain	Straw
15th October	11·80	27·90	20·60	80·00	14·17	37·38
22nd October	..	..	..	..	19·28	49·04
29th October	..	..	..	..	16·68	43·61
30th October	15·05	45·18	21·00	70·80	..	..
5th November	..	..	..	..	17·08	47·23
12th November	..	..	..	..	15·47	42·41
14th November	13·84	42·39	23·40	67·00	..	..
S. E.	0·63	1·31	1·50	1·51	0·92	1·46
C. D. 5 per cent	non-sig.	3·92	non-sig.	non-sig.	non-sig.	non-sig.

A comparison of the data for different years in Table II indicates that the trend of yield in the first and third year of the experiment was different from that in the second year. The yields of both grain and straw in the first and third year had been much reduced in the case of early sowing (15th October) while in the second year the grain yield had undergone only a slight reduction and that of straw has tended to improve. All the results are statistically non-significant except for straw in the year 1948-49. It is, however, clearly indicated that 15th October is too early for sowing wheat in this tract. The proper time appears to range from last week of October to the first week of November. Late sowings (12th to 14th November) have consistently given reduced yields of straw while for grain only the year 1949-50 proved better.

TABLE III

Grain and straw yields under different seed rates (in md. per acre)

Seed rates	1949-50		1950-51		Average	
	Grain	Straw	Grain	Straw	Grain	Straw
30 srs./acre	22·90	70·80	16·62	44·00	19·71	57·40
40 srs./acre	20·60	72·80	16·75	44·01	18·67	58·40
50 srs./acre	21·60	74·20	16·84	43·81	19·32	59·00
S. E.	0·82	1·50	0·72	1·13	..	..
C. D. 5 per cent	non-sig.	non-sig.	non-sig.	non-sig.	..	..

The variations in the grain and straw yields due to seed rates were non-significant in both the years. However, in the first year (1949-50) the grain yield at 30 seers seed rate was greater by 10·0 per cent and 5·7 per cent than the yields obtained at 40 and 50 seers seed rates respectively. But the straw yields showed an improvement of 3 to 5 per cent with the increase in the seed rates from 30 to 40 and 50 seers per acre in the same year; the gain being of less value than the cost of extra seed. In the second year the yields of both grain and straw under all the three seed rates were practically the same. A seed rate of 30 seers per acre, therefore, is optimum for this tract as regards the production of both grain and straw.

Among the various interactions, the grain yield was found to be significantly affected only by the interaction between seed rates and varieties in the year 1949-50. Likewise, the yield of straw was significantly affected by the interaction of dates and varieties in the year 1949-50 and that of varieties and seed rates in the year 1950-51 (Table IV).

TABLE IV

Interaction of varieties and seed rates on the grain yield, 1949-50

(*md. per acre*)

Varieties	Seed rates per acre			S.E.	C D. 5 per cent
	30 srs.	40 srs.	50 srs.		
'Local'	22·58	16·46	16·76	..	..
Pb. 591	25·04	26·40	26·04	1·49	4·14
C. 13	21·18	18·96	21·82	..	..

It is evident from the above results that *Pb. 591* at 40 seers seed rate gave the highest yield of grain per acre and *'Local'* at the same seed rate, the lowest *Pb. 591* and *C. 13* did not show any consistent and significant variations in the grain yield with the increase in the rate of seed from 30 to 40 and 50 seers. But the yield of *'Local'* at 30 seers seed rate was significantly higher than the yields at the other two seed rates, between which there was practically no difference. On the whole it may be concluded that a seed rate of 30 seers per acre is quite suitable for each variety. Seed rates higher than this may not affect the yield of *Pb. 591* and *C. 13* but cause a significant decrease in case of *'Local'*.

TABLE V

Interaction of varieties and sowing dates on straw yield, 1949-50

(*md. per acre*)

Dates	Varieties			S.E.	C.D. 5 per cent
	Pb. 591	C.13	'Local'		
15th October	78·19	75·25	87·16	..	..
30th October	77·47	65·10	69·80	2·72	7·54
14th November	70·60	65·20	64·90	..	..

There are clear indications that early sowing (15th October) is the best from the point of view of straw production regardless of variety and that the yield tends to fall with delay in sowing. '*Local*' when sown early, produced significantly more straw per acre than *Pb. 591* and *C. 13*. The position changed in case of mid (30th October) and late (14th November) sowings, when *Pb. 591* consistently gave appreciably greater yields than *C. 13* and '*Local*', the differences being significant in the case of mid-sowing but non-significant in case of late-sowing. However, the yields of *C. 13* and '*Local*' obtained from these sowing dates (30th October and 14th November) had only small variations not of much practical value.

Early sown *Pb. 591* closely followed by mid-sown showed appreciable but non-significant increase in straw yield over the late-sown crop. In case of *C.13* and '*Local*' early sowing produced significantly more than mid and late sowings. On the whole it may be summed up that for a better yield of straw *C.13* and '*Local*' need to be sown as early as 15th October while *Pb. 591* may be sown up to 30th October without any loss in straw yield.

TABLE VI

Interaction of varieties and seed rates on the straw yield, 1950-51

(*md. per acre*)

Varieties	Seed rates per acre			S.E.	C.D. 5 per cent
	30 srs.	40 srs.	50 srs.		
Pb. 591	47·14	50·80	51·02	1·60	4·54
C.13	40·50	37·16	36·40	..	..

The results reveal a contrasting trend between *Pb. 591* and *C. 13* in straw production under the three rates of seeding. While the yield of *Pb. 591* improved by about 8 per cent with the increase in the seed rate from 30 seers to 40 and 50 seers per acre, *C.13* experienced a decrease of 8 to 10 per cent. Further, it is seen that *Pb. 591* produced significantly greater amount of straw per acre than *C.13* at every rate of seeding. It suggests, that like grain yield (Tables I and IV), *Pb. 591* is superior to *C.13* in the production of straw also and that its seed rate could be increased to 40 seers per acre with advantage while in the case of *C.13* a seed rate above 30 seers results in a decrease in straw production.

DISCUSSION

The utilisable yield in wheat in India is represented by grain and straw produced by the plant at the end of its growth and developmental activities, which in turn are controlled by the hereditary potential of the variety and the environmental conditions to which it is subject during its life cycle. In the course of the experiments, various agronomical characters of growth and development were studied which have been made use of in the discussion of the yield results presented above. The data on these have been summarised in the Appendix I, II and III.

In the present series of experiments *Pb. 591* has shown better yield than *C.13* and '*Local*'. This could be attributed to its being generally superior to *C.13* and '*Local*' in respect of majority of yield contributory characters like, total dry matter per plant, number of ear bearing tillers per plant, number of grains per ear and test weight (Appendix I). Moreover, *C.13* and '*Local*' have been found to be more damaged by rust in this area.

Seed rates ranging from 30 seers to 50 seers have shown practically no difference in the yield of both grain and straw. This may be due to the better growth and development of individual plants as evidenced by the total dry matter production per plant (Appendix II) in thin sown crops as a result of reduced competition between plants. The crop density results at harvest revealed that the number of plants in one square yard in higher seed rate treatments was generally higher than in the lower seed rate treatment. But this advantage in favour of thick sowings was equalled by the other yield contributory factors in favour of thin sowings. Howard and Howard [1909], Grantham [1917], Leighty and Taylor [1927] and Hutchinson [1936] have reported that provided all the conditions were the same, variations in seed rate made little difference in yield.

The grain yield under different sowing dates have not differed significantly in any of the years of experimentation but the yields from early sowing, i.e. 15th October, were consistently lower. This has been found to be due to the high mortality in seedlings during the early life of the crop, brought about by the high atmospheric temperatures during the first three weeks of October and also increased white ant activity both of which resulted in lower crop density at harvest (Appendix III). The optimum time for sowing wheat in Agra appears to be towards the end of October to early November (22nd October to 5th November). Further, it has been observed that sowings done too late (2nd week of November) tend to decrease yields as a result of lower dry matter production per plant due to the slowing down of vegetative activity brought about by low temperatures, with the onset of winter. Leighty and Taylor [1927] and Singh and Alam [1944] recorded poor yields in delayed sown crops. In the present experiments, in 1949-50, the late sown crop (14th November) gave the best grain yield which is traced to the higher fertility ratio of spikelets in the ear leading to a greater number of grains per ear (Appendix III). This appears to be due to the incidence of frost in this year during the period 10th to 17th February (minimum temperature 37 ° F. on 11th and average minimum for the week 42°F.). Due to late flowering, in the crop of 14th November grain formation was not affected as the pollen shedding stage was reached after the low temperature period. It has been shown by Tippett [1926] that pollen may be killed in cereals by low temperatures which do not destroy other portions of the plant.

The interactions between varieties and seed rates for the grain yield (1949-50) and straw yield (1950-51), indicate that *Local* is adversely affected by increasing the seed rate from 30 to 40 and 50 seers per acre while *Pb. 591* tends to do better at 40 seers per acre. This appears to be due to generally lower density of plants in *Pb. 591* crop at harvest (Appendix I).

Summary

The results of a series of experiments conducted at the Balwant Rajput College Experimental Farm, Bichpuri, Agra from 1948-49 to 1950-51 on the performance of different wheat varieties (*Pb. 591*, *C.13* and *Local*) at different seed rates (30, 40 and 50 seers per acre) and sowing dates (15th October to 14th November) have been discussed.

The results of three years reveal *Pb. 591* to be the suitable variety, 30 seers per acre as the optimum seed rate and October end to early November (22nd October to 5th November) as the optimum time for wheat sowing in Agra tract. However, study of significant interactions give an indication that a seed rate upto 40 seers per acre may benefit *Pb. 591* but *Local* would be adversely affected.

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APPENDIX I

Data on yield contributory factors for varieties

Characters	1948-49			1949-50				1950-51		
	Pb. 591	C. 13	S.E. C.D. 5 Per cent	Pb. 591	C. 13	Local	S.E. C.D. 5 Per cent	Pb. 591	C.13	S.E. C.D. 5 Per cent
Total dry matter per plant (gm.)	26·04	25·23	1·00 non-sig.	34·99	26·15	29·96	2·34 6·50	16·99	13·07	0·53 1·46
Ear bearing tillers per plant	4·43	4·54	0·18 non-sig.	5·85	5·16	5·60	0·26 non-sig.	3·68	3·02	0·11 0·31
Number of grains per main shoot ear	54·54	46·04	1·04 3·00	38·50	36·20	20·40	1·95 5·40	41·00	39·90	0·75 non-sig.
Weight of 1000 kernels in gm.	40·51	42·53	0·48 1·38	40·80	38·90	37·80	0·60 1·64	41·33	38·52	0·40 1·10
Density of plants per sq. ft.	..	..	..	35·90	51·10	53·50	3·14 8·71	26·41	26·60	1·00 non-sig.

APPENDIX II

Data on yield contributory factors for seed rates

Characters	1949-50				1950-51			
	30 srs.	40 srs.	50 srs.	S.E. C.D. 5 per cent	30 srs.	40 srs.	50 srs.	S.E. C.D. 5 per cent
Total dry matter per plant in gm.	30·37	28·78	27·25	2·34 non-sig.	16·53	14·65	13·92	0·68 1·88
Ear bearing tillers per plant	5·60	5·60	5·40	1·25 non-sig.	3·58	3·29	3·17	0·14 non-sig.
Number of grains per main shoot ear	35·30	33·00	34·00	1·95 non-sig.	40·40	41·50	39·40	0·93 non-sig.
Weight of 1000 kernels in gm.	39·20	39·90	39·20	0·60 non-sig.	38·84	40·22	39·73	0·47 non-sig.
Density of plants per sq. ft.	47·20	44·00	50·20	3·14 non-sig.	23·74	26·68	29·09	1·26 3150

APPENDIX III

Data on yield contributory factors for sowing dates

Years and seeding dates	Total dry matter per plant in gm.	Ear bearing tillers per plant	Number of grains per main shoot ear	Weight of 1000 kernels in gm.	Density of plants per Sq. ft.
1948-49					
15th October	28·27	5·49	55·49	45·94	Not available
30th October	28·53	4·56	50·96	41·95	
14th November	20·55	3·40	43·89	36·72	
S.E.	2·00	0·34	2·94	1·50	
C.D. 5 per cent	5·84	·99	8·51	4·31	
1949-50					
15th October	44·00	7·22	32·80	39·70	30·70
30th October	25·18	5·01	27·80	41·10	56·20
14th November	18·22	4·35	41·80	36·60	53·80
S.E.	3·57	0·46	3·03	0·84	4·42
C.D. 5 per cent	9·85	1·28	non-sig.	2·32	12·25
1950-51					
15th October	19·32	4·00	41·80	42·42	19·88
22nd October	15·26	3·36	41·00	40·95	31·05
29th October	14·84	3·15	40·30	39·55	27·64
5th November	14·47	3·33	39·80	38·34	28·99
12th November	11·25	2·93	39·30	37·83	25·01
S.E.	2·60	0·18	1·21	0·64	1·59
C.D. 5 per cent	non-sig.	non-sig.	non-sig.	1·76	non-sig.

QUALITY OF IRRIGATION WATERS IN UTTAR PRADESH

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(With two Text-Figures)

IN the State of Uttar Pradesh in India there are about 38 million acres of cultivated land, nearly 30 per cent of which are irrigated. Most of the area receives its irrigation water supply from small hand dug wells of varying depths depending on the ground water level. These wells replenish their water supplies from the annual monsoon rains which percolate through the soil and feed the water strata of the wells. Quite a significant portion of this irrigated land meets its water requirement from a network of canals which have been constructed during the last 100 years. The rapid pace of irrigation development in the more arid western tracts of the State, together with simultaneous occurrence of vast areas of saline and alkali soils necessitate a critical examination of the quality of irrigation waters. Very little information is available in the literature on the quality of irrigation waters of this country in general and of the Gangetic alluvium in particular since very few publications have dealt with this problem. Asghar and Dhawan [1947] studied the waters from drains, rivers and canals of the Punjab in respect of their conductivity, total salt content and *p*H values, etc. They have made comparison of relationships between the total salt content, calcium-sodium ratio and *p*H values with the "salt index" proposed by Taylor, Puri and Asghar [1955]. Chemical composition of a number of irrigation water samples have been reported by Agarwal and Mehrotra [1952-1953]. Most of these investigations have been of an exploratory nature and pertain to limited areas.

Literature on this subject, in the other parts of the world, has been found to be very extensive. Numerous methods of analysis, interpretation and categorization of waters in suitability classes have been worked out and adopted by various workers. The most pioneering work in this branch has been done in the United States, specially in the West and particularly at the U. S. Salinity Laboratory, Riverside, California. Very voluminous data have been collected and published by the U. S. Geological Survey pertaining to waters from all over that country. Comprehensive methods of laboratory examination of irrigation waters and a tentative scheme of classification were initially proposed in the preliminary Manual of the U. S. Salinity Laboratory,

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edited by Richards [1947]. The progress of entire work was reviewed by Wilcox [1948] in his technical bulletin wherein he also proposed a water classification system. Other outstanding works are Eaton [1950], Wilcox and his associates [1951] and Thorne and Thorne [1951].

Latest advancements in regard to the examination and categorization of irrigation water samples have been reported in a recent Manual of the U. S. Salinity Laboratory (1954). In this manual, a new expression of sodium hazard has been introduced which is termed as sodium-adsorption-ratio (SAR). This ratio is related to the adsorption of sodium by the soil from salt solutions or irrigation waters and is, therefore, a definite improvement over previous indices for sodium or alkali hazard from irrigation waters. The waters have been categorized into four grades of salinity, denoted as C1 to C4, and four grades of alkalinity, expressed as S1 to S4, in the form of SAR values, making up 16 classes in all. This classification has been represented by the workers of the U. S. Salinity Laboratory on a diagram.

Material and Methods

The work was started in Uttar Pradesh by the present authors in consideration of severe salinity and alkali soil problems existing in the western and central districts of the State where the intensity of irrigation is the heaviest. To start with, three districts were selected as typical of these areas in the Gangetic alluvium. The data on the quality of irrigation waters, on the lines proposed by the U. S. Salinity Laboratory, have been obtained in the course of this examination which have been reviewed and discussed in the light of suggestions made in some of the classificational systems referred to above. Table I gives the extent of area served by different sources of irrigation in the three districts of Etah, Farrukhabad and Kanpur. It may be seen that the total areas irrigated in these districts vary from 48 to 30 per cent. Kanpur has the largest percentage of canal irrigated area whereas Farrukhabad shows the largest percentage of well irrigated area.

Water samples from various sources such as canals, shallow dug wells, etc. were collected from a number of places in the above districts. The time of collection of these samples was kept as uniform as possible and in all the cases the samples were drawn when the water was being freely taken out for irrigation purposes. The parent source of all the canal waters was either the main lower Ganges Canal or its distributaries. Since the quality of ground water is considerably influenced by the nature of the soil, the depth of the water bearing strata and other environmental factors, well water samples were collected from sites well distributed on all important soil associations in each district. The depth of water in these wells varies with the maturity of the soil and whereas it stands at about 6 ft. in the newly deposited areas it may drop to 30 or 40 ft. in fully mature soil regions. The detailed characteristics of these soil associations have been described by the authors [1952-1953] and characteristics of some of the saline and alkali soils of Gangetic alluvium of this State have been given in a recent publication by Agarwal and Yadav [1954].

TABLE I

Showing the extent of area served by different sources of irrigation

Particulars	Etah	Farrukhabad	Kanpur
Total area (acres)	1,097,984	1,060,508	1,517,239
Area cropped (average) (acres)	731,000	635,000	874,000
Area irrigated (acres)	350,356	192,074	292,888
Per cent irrigated to total cropped	47·9	30·2	33·5
Irrigated through :			
(*a*) Canals (acres)	188,904	84,445	259,716
Per cent of the total irrigated area	53·9	43·9	88·6
(*b*) Tubewells (acres)	11,703	494	98
Per cent of the total irrigated area	3·3	0·2	0·04
(*c*) Gravity-wells (acres)	135,919	96,502	24,446
Per cent of the total irrigated area	38·7	50·2	8·3
(*d*) Other sources (acres)	13,830	10,633	8,628
Per cent of the total irrigated area	3·9	5·9	2·9
Number of gravity wells (1950-51)	38,864	48,375	22,975

The water samples reported in this paper were collected only from the four soil associations of the Ganga system in each of the districts under study. Each sample was completely analysed for cations and anions by the usual laboratory methods. The difference of total anionic concentration and the sum of bivalent cations, viz. Ca and Mg has been taken as total monovalents which consist mostly of sodium, there being very little postassium. This fact was verified in a number of the cases by determination of individual cationic contents. Total salt concentration was measured as electrical conductivity. *p*H values were determined on a line operated Macbeth *p*H meter. In cases where conductivity measurements could not be taken, total salts were estimated by drying and weighing and expressed as parts per million. For maintaining uniformity in the presentation of the data these figures have been converted into electrical conductivity values by dividing with the conversion factor=0·64, as worked out at the U. S. Salinity Laboratory and reported in their manual (1954).

Sodium percentage were calculated as $Na \times 100/\text{total cations}$; possible sodium percentage as $Na \times 100/(\text{total cations}) - (CO_3 + HCO_3)$ and residual alkalinity as $(CO_3 + HCO_3) - (Ca + Mg)$. The sodium-adsorption-ratio values were obtained by the relationship $Na/\sqrt{(Ca+Mg)/2}$.

Experimental

The analytical values for well water samples obtained in these studies were averaged on the basis of soil associations in each district. The average composition thus obtained for each soil region is presented in Table II. The deviations observed in electrical conductivity and per cent sodium in each of the soil regions are given in Table III along with some of the derived ratios calculated for assessing the water quality.

An examination of the data presented in Table II reveals that the composition of well waters in all the three districts is, in general, one of high salt content. The highest contents of dissolved salts are generally met with in recently deposited soil areas while the lowest are found in the mature high lying soil regions. The dissolved salts are mostly composed of bivalent cations in mature soil areas while newly deposited and azonal soil areas possess greater proportions of monovalent cations. The anionic portions of almost all the waters contain predominantly bicarbonate ions, carbonates being significant only in Kanpur district where also the values have not exceeded 11 per cent of the total anions. Toxic concentrations of chloride ions are noticeable in waters which have high salt contents. Sulphate ions are present in smaller quantities except in areas having newer alluviums. Almost all the waters are slightly to moderately alkaline in reaction, the *p*H value varying from 7·9 to 8·2 in Etah, 7·2 to 8·5 in Farrukhabad and 8·6 to 8·8 in Kanpur district. Nitrate estimation values are available only in a few cases, but whatever values have been collected show that nitrate contents are high in newly deposited areas and only in traces in old and mature soil regions.

TABLE II

Average chemical composition of irrigation water in Indian Gangetic alluvium

District	Soil region	Nature of soil formation	No. of samples	pH	Electrical conductivity micromhos/cm.	Cations m.e/l			Anions m.e/l					Total Ionic concentration m.e/l
						Ca	Mg	Na	CO_3	HCO_3	Cl	SO_4	NO_3	
						Well waters								
Etah	Etah loamy sand	Recently deposited	5	7·9	1132	4·09	3·25	4·93	0·24	8·24	1·92	1·86	..	12·27
	Etah loam	Mature	19	8·1	613	2·49	1·63	2·92	0·41	5·29	0·57	0·79	..	7·05
	Etah clay loam	Mature	11	8·0	600*	2·75	1·11	2·35	0·12	4·55	0·61	1·02	..	6·21
	Etah sandy loam	Immature	16	8·2	1806	3·20	1·50	8·31	0·25	6·51	3·31	2·94	..	13·01
Farrukhabad	Farrukhabad loamy sand	Recently deposited	18	7·2	2289	3·89	5·31	11·99	0·01	10·64	6·08	3·54	0·92	21·19
	Farrukhabad loam	Mature	19	7·9	845	2·56	2·08	3·02	0·03	6·08	0·93	0·47	0·15	7·66
	Farrukhabad loam (Halomorphic)	Saline	9	8·5	1301	1·81	2·28	7·46	0·27	7·52	2·47	0·98	0·31	11·55
	Farrukhabad sandy loam	Mature	11	7·9	722	2·94	2·38	1·29	0·12	5·11	0·74	0·64	Tr.	6·61
	Farrukhabad clay loam	Mature low-lying	7	7·6	820	2·78	2·36	2·33	0·15	5·94	0·88	0·50	*nil*	7·47
Kanpur	Kanpur loamy sand	Recently deposited	5	8·8	1982	1·75	2·93	12·40	2·12	7·34	4·72	2·90	..	17·08
	Kanpur loam	Mature	9	8·6	977	1·13	1·62	7·06	1·46	7·13	0·76	0·45	..	9·81
	Kanpur sandy loam	Mature	3	8·6	812	1·38	1·40	5·72	1·37	5·42	1·08	0·63	..	8·50
	Kanpur clay loam	Mature	5	8·7	1726	1·58	1·93	9·80	1·94	7·90	2·07	1·40	..	13·31
						Canal waters								
Etah	Lower Ganges Canal		9	8·2	365*	1·78	0·44	1·54	0·13	2·03	0·24	1·35	..	3·76
Farrukhabad	Do.		4	7·8	264	1·40	0·67	0·47	*nil*	1·90	0·14	0·50	..	2·54
Kanpur	Do.		23	8·5	444	1·15	0·60	2·35	0·34	2·74	0·26	0·32	..	4·11

Figures marked * include some values obtained by calculation from total salt contents in ppm.

TABLE III

Derived ratios for different irrigation waters

Deviations				Per cent sodium		Residual Alkalinity $(CO_3+HCO_3)-(Ca+Mg)$	S.A.R. value $\frac{Na}{\sqrt{(Ca+Mg)/2}}$	Water quality
Electrical conductivity		Per cent sodium		Observed $\frac{Na\times100}{}$	Possible $\frac{Na\times100}{}$			
Maximum	Minimum	Maximum	Minimum	Total	Total (CO_3+HCO_3)			
				Etah well waters				
1612	947	62	31	40	100	1·14	2·57	C3-S1
1010	329	63	22	42	100	1·58	2·04	C2-S1
1103	344	72	1	38	100	0·81	1·69	C2-S1
3398	472	88	29	64	100	2·06	5·42	C3-S2
				Farrukhabad well waters				
5618	688	93	16	57	100	1·45	5·59	C4-S2
1377	505	66	1	39	100	1·47	1·98	C3-S1
2443	1010	84	49	65	100	3·70	5·22	C3-S1
1575	303	40	8	20	94	—*nil*—	0·69	C2-S1
1049	583	48	18	31	100	0·95	1·45	C3-S1
				Kanpur well waters				
276	959	87	32	73	100	4·78	8·10	C3-S2
1848	689	88	51	72	100	5·84	6·02	C3-S2
1010	583	73	60	67	100	4·01	4·85	C3-S1
3153	1010	89	57	74	100	6·33	7·40	C3-S2
				Canal waters				
444	278	61	0	41	97	—*nil*—	1·46	C2-S1
271	261	28	7	19	73	—*nil*—	0·46	C1-S1
779	329	84	17	57	100	1·23	2·52	C2-S1

The canal waters present somewhat different picture inasmuch as a more uniform composition has been obtained from waters of all the three districts. Salt contents are low and the predominating cations in these waters are generally the bivalent calcium and magnesium, monovalents being 41 per cent in Etah, 10 per cent in Farrukhabad and 57 per cent in Kanpur canal waters. The anionic portion is dominated by bicarbonate ions, chlorides and carbonate contents being very little. Significant quantities of sulphate ions have been obtained in canal waters of Etah district. These waters are also slightly to moderately alkaline in reaction, the maximum alkalinity having been obtained towards the very tail end of canal in Kanpur District.

Discussion

According to the earlier water categorization systems proposed by the U. S. Salinity Laboratory and subsequently modified by Wilcox [1948], well waters from mature soil regions in general fall under "Excellent" or "Good" category waters while waters from the newly deposited alluvial areas or azonal regions fall under "Good to Injurious", "Permissible" or even "Doubtful" quality. These have been found to have somewhat higher proportions of sodium in comparison with the prescribed limits. Canal waters on the other hand fall under "Excellent" or "Good" quality waters for irrigation purposes.

In terms of Eaton's [1950] water categorization, however, many of these well waters would fall under the poorest quality of waters because of the general preponderance of carbonate and bicarbonate ions over the bivalent cations. These waters according to Eaton on concentration are liable to damage the root zone rather severely as is evident from the values of "Possible sodium" and "Residual Alkalinity". Canal waters seem to be free from such dangers of inherent alkalization. The system, however, does not seem to suit the conditions of Uttar Pradesh especially in view of the fact that no appreciable damage seems to have been caused through the constant and long term use of these well waters on these soils. This may possibly be due to the very low quantities of well waters applied for irrigating the crop, good inherent permeability especially on mature soils and enough monsoon rainfall to leach out any residual salts.

The water analysis data were also compared in detail with the latest water categorization system put forward by the U. S. Salinity Laboratory in their Manual [1954] wherein use of SAR values, apart from the salinity classes, have been made in place of sodium percentage for assessing the sodium hazard. All the 173 samples, in the present study, were classified firstly into the five conductivity classes. Table IV shows the distribution of these waters amongst the different classes and the frequency distribution on this basis has been indicated in Fig. 1.

Table IV

Distribution of water amongst conductivity classes

Conductivity range (micromhos/cm) at 25°C	Number of sample	Per cent
<250	1	1
251—750	83	48
751—2250	77	44
2250—5000	10	6
>5000	2	1
Total	173	100

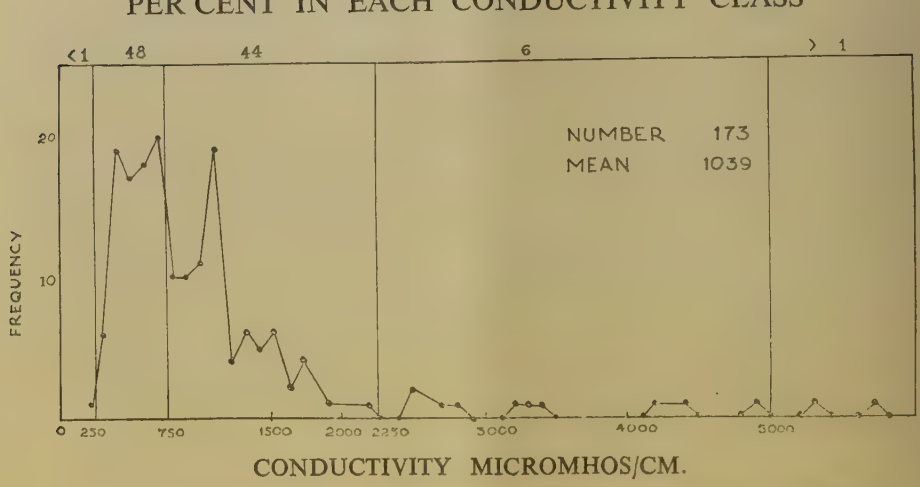

FIG. 1. Frequency distribution of irrigation water with respect to electrical conductivity

It may be seen from the two presentations that out of 173 samples, as much as 160 fall under medium and high conductivity classes both sharing evenly. Only a few samples pass into very high conductivity class. Average values of conductivity representing different soil regions, as presented in Table II, indicate that all the well waters of Kanpur district, recently deposited soil areas of Etah and all but one soil regions of Farrukhabad district can be categorized in high or very high salinity class. Waters from the mature soil regions in the districts of Etah and Farrukhabad conform to medium salinity class. Though remarkable deviation, as shown in Table III, is noticed in the values of conductivity, there are very few samples within each class which show such deviations. The majority of the samples are near the values indicated by averages.

The values of sodium-adsorption-ratio (SAR) calculated for all the water samples were also utilized along with the conductivity values for classifying waters. For this purpose, use has been made of the diagram adopted by the workers of the U.S. Salinity Laboratory and the values for individual samples have been plotted thereon and shown as Fig. 2. It can be seen from this diagram that well waters of the area under study, in general, fall under the water quality classes C2-S1 and C3-S1. Some samples have also been found to fall in C3-S2 class. In other classes of higher conductivity and alkalinity only a few isolated samples have been encountered. Canal waters, in general, fall into C1-S1 and C2-S1 classes. The average values of sodium-adsorption-ratio as calculated for different soil regions as well as their water quality class are given in Table III. These figures reveal that the waters from the mature soil regions of Etah correspond to C2-S1 class and the immature areas of Ganga and Yamuna system pass into C3-S1 and C3-S2 classes respectively. Fully mature soils in Farrukhabad also possess good quality water like those of Etah district. Immature Farrukhabad loamy sand areas pass into C4-S2 class while other areas correspond to C3-S1 class. In Kanpur district all the water samples except those of sandy loam areas fall into C3-S2 class, this area being in C3-S1 category. Canal waters correspond to the class C2-S1 with some exceptions in Farrukhabad where the best quality, viz. C1-S1 waters are met with.

In the light of the above discussion it can be inferred that waters from the canal network of this State are of safe quality and need no supplemental practices in their use. The well waters on the other hand have high salt content specially in hydromorphic and halomorphic soil areas. Such waters are liable to create appreciable salt problems and in many cases sodium hazards. Their use, especially in fine textured soils, will require occasional treatment with soluble calcareous amendments. In coarse textured soils such waters may not present serious problems in view of the existing conditions of climate and sparse irrigation usually practised on them. Well waters of mature soil regions are of average quality and not much salt problem should be feared from their use, even though the salt contents of these waters are slightly high. This is due to low water table, good subsoil permeability and the existing climatic conditions where a precipitation of about 30 to 35 in. is received annually during the monsoons.

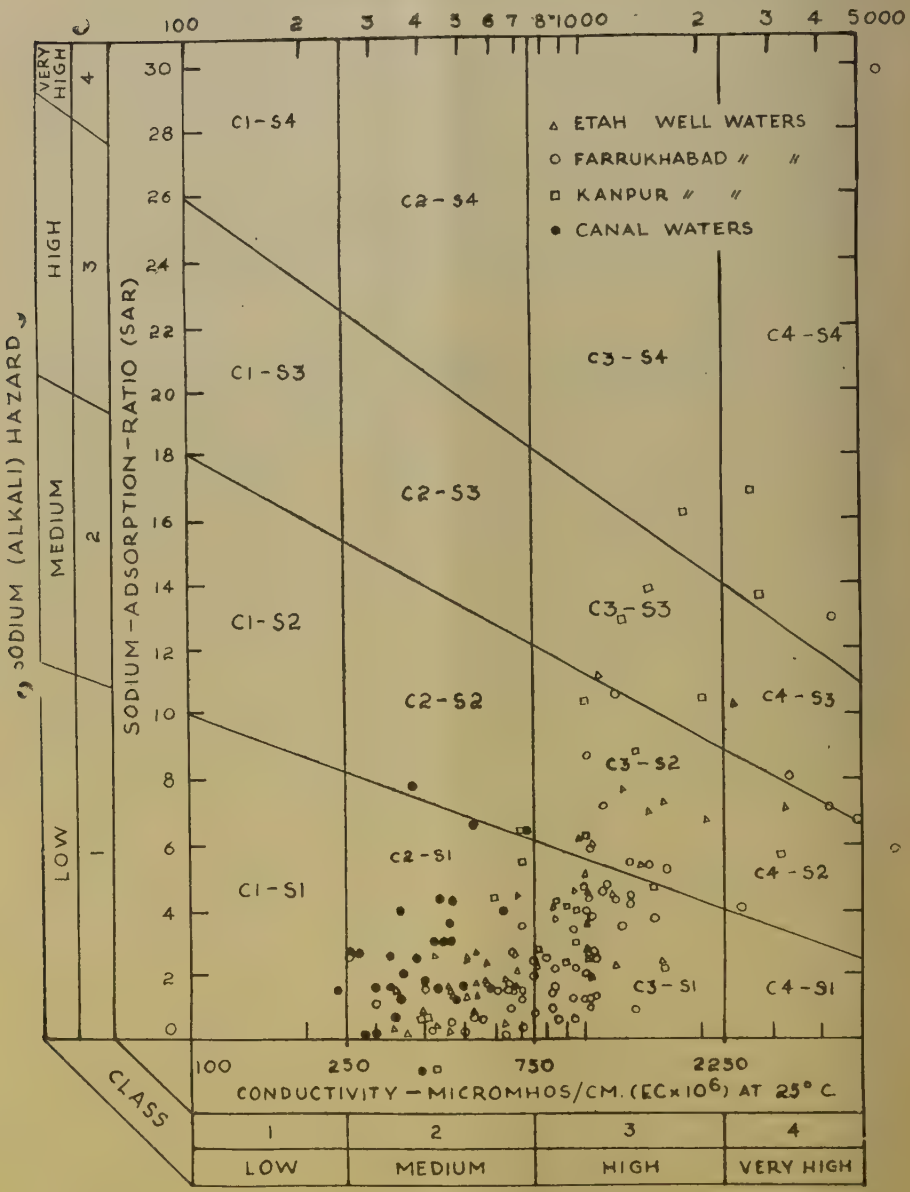

FIG. 2. Diagram showing quality of irrigation waters

Summary

Different sources of irrigation waters in the central western portions of the Gangetic alluvial region of Uttar Pradesh were examined in detail.

The irrigation waters from canals have been found to be of safe quality and constitute the best source of irrigation water supply of this State.

The quality of well waters has been found to vary with the nature of the soil formation and its ground water levels. Immature and azonal soils contain well waters of doubtful quality and may present soil salinity problems. Well waters on mature soils are comparatively free from salinity dangers.

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AMINO ACID CONTENT OF GRASSES AND LEGUMES

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GRASSES and legumes constitute a major portion of the animal ration and a thorough knowledge of the nutritive value of different species found in the country is important to make a judicious selection and cultivation of good fodders. The importance of the constituent essential amino acids of proteins in grasses and legumes in assessing their nutritive value cannot be over-emphasised. In view of this fact three important amino acids, such as, tryptophane, methionine and cystine have been estimated in a few indigenous grasses and legumes. Similar data on Indian grasses and legumes are not available.

The percentage release and stability of the sulphur containing amino acids under different conditions of hydrolysis have also been studied in the light of earlier observations. [Lyman *et al.*, 1946 ; Miller *et al.*, 1950 ; Chang and Murray, 1949 ; Kelley and Baum, 1953 ; Gupta and Das, 1954 ; Gupta and Das, 1955.]

Material and Methods

Legumes and grasses analysed here were grown at the Agronomy Division of this Institute.

Sampling. The grasses and legumes were freshly cut and dried quickly in the oven. The dried samples were ground in a mortar and kept in bottles. Representative portions of the samples were analysed for methionine, cystine and tryptophane.

Methods of assay. For the extraction of methionine, grasses and legumes were hydrolysed by autoclaving for two hours, one hour, and half an hour at 15 lb. pressure with 25 cc. 2N HCl while for cystine the same were hydrolysed for six hours, three hours, two hours and one hour at 15 lb. pressure with 25 cc. 2N HCl. The extracted samples were then assayed microbiologically with the help of *Leuconostoc mesenteroide P—60* as described earlier [Gupta and Das, 1954 ; Gupta and Das, 1955].

Tryptophane was extracted according to Vijayaraghavan and Srinivasan [1953] and then estimated with the help of *Lactobacillus arabinosus* 17/5 as reported earlier.

Results

In order to find out the conditions for the maximum release of methionine and cystine from the legume and grass proteins, the samples were hydrolysed by autoclaving for different periods at a pressure of 15 lb. with 25 cc. 2N HCl. The value for methionine and cystine at the end of different periods of hydrolysis are given in Table I and II.

TABLE I

Methionine content after different periods of hydrolysis

(*Percentage on oven-dry basis*)

Samples	2 hours	1 hour	½ hour
Legumes :			
Berseem	0·54	0·56	0·51
Lucerne	0·54	0·54	0·50
Grasses :			
Cortadenia argentina	0·082	0·09	0·074
Dichanthium annulatum	0·25	0·27	0·20

It appears from the above figures that autoclaving for one hour is sufficient for the optimum release of methionine from the legume and grass proteins.

TABLE II

Cystine content after different periods of hydrolysis

(*Percentage on oven-dry basis*)

Samples	6 hours	3 hours	2 hours	1 hour
Lucerne	0·082	0·091	0·087	0·083
Vicia sativa	0·061	0·079	·071	0·074
Grasses :				
Dichanthium annulatum	0·043	0·049	0·046	0·046
Phalaris tuberosa	0·040	0·049	0·045	0·042

Autoclaving for three hours seems to be adequate for the maximum release of cystine from legume and grass proteins. There appears to be slight loss of cystine when hydrolysed for six hours.

In view of the above findings, different legumes and grasses were hydrolysed by autoclaving for one hour and three hours for the estimation of methionine and cystine respectively. Besides shorter period of hydrolysis, the other advantage of autoclaving lies in the fact that the smaller quantity of HCl need not be removed under vacuum distillation as is necessary in the case of hydrolysis by refluxing.

The methionine, cystine and tryptophane contents of different legumes and grasses, analysed according to the methods described here are given in Tables III and IV respectively.

TABLE III

Methionine, cystine and tryptophane content of legumes

(*Percentage on oven-dry basis*)

Legumes		Country of origin	Methionine	Cystine	Tryptophane	Protein
Botanical name	Common name					
Lupinous termis	..	India	0·275	0·022	0·056	12·8
Trifolium alexandrinum	L. Berseem	India	0·560	0·039	0·119	25·86
Medicago sativa L.	Lucerne	India	0·540	0·049	0·131	26·50
Vicia sativa	..	India	0·260	0·058	0·158	26·43
Melilotus alba Desv	Hubam clover	India	0·450	0·068	0·116	24·93
Medicago hispida	Bur clover	India	0·200	0·031	0·083	18·00
Desmodium purpureum	..	India	0·416	0·068	0·077	20·00
Clitoria ternatea	..	India	0·418	0·142	0·086	25·18
Centrosema pubescens	..	India	0·439	0·058	0·065	26·06
Desmodium cephalotes	..	India	0·180	0·024	0·046	15·62
Cyamopsis tetragonoloba Taub	*Guar*	India	0·212	0·039	0·142	24·62
Desmodium scorpiurus	..	Australia	0·257	0·027	0·063	15·19

Methionine

Legumes are found to differ considerably in their methionine content. Its content is highest (0·56 per cent) in Berseem and lowest (0·18 per cent) in *Desmodium cephalotes*. The Australian legume *Desmodium scorpiurus* is found to be low in methionine content (0·251 per cent) as compared to some of the Indian legumes. Methionine content of these legumes is relatively higher than that of cystine and tryptophane.

Cystine

Cystine contents of legumes studied here, also differ considerably, varying from 0·024 (*Desmodium cephalotes*) to 0·142 (*Clitoria ternatea*) per cent. The Australian legume (*Desmodium scorpiurus*) appears to be poorer in this amino acid when compared with some of the Indian legumes. Among the three amino acids studied, cystine content is the poorest in these legumes.

Tryptophane

Tryptophane varies from 0·046 per cent (*Desmodium cephalotes*) to 0·0158 per cent (*Vicia sativa*) and is richer than cystine but poorer than methionine. Different legumes also differ considerably among themselves in the content of this amino acid. As in the case of methionine and cystine, the Australian legume (*Desmodium scorpiurus*) is again found to be low in tryptophane content when compared to these Indian legumes.

It appears that no correlation exists among the three amino acids but *Desmodium cephalotes* contains low content of all the three amino acids studied here.

Protein

The protein content of these legumes differ considerably varying from 12·81 (*Lupinous termis*) to 26·50 (Lucerne) per cent, Australian legume (*Desmodium scorpiurus*) containing 15·19 per cent is lower than most of the Indian legumes.

Correlation between the different amino-acids of the legumes studied

Correlation between the following pairs of constituents were studied statistically and the results are given below:

Constituents	Correlation Coefficient (r)
Methionine and cystine	+0·4080 Not significant
Methionine and tryptophane	+0·2400 Not significant
Methionine and protein	+0·6136 Significant
Cystine and protein	+0·5232 Not significant
Tryptophane and protein	+0·7445 Significant
Cystine and tryptophane	+0·1509 Not significant

The relationship between protein-methionine and protein-tryptophane is significant and positive. The other pairs show no significant relation between them.

TABLE IV

Methionine, cystine and tryptophane contents of grasses

(Percentage on oven-dry basis)

Grasses		Country of origin	Methio-nine	Cystine	Trypto-phane	Protein
Botanical name	Common name					
Setaria sphacelata	..	E. Africa	0·153	0·185	0·0203	7·31
Brachiaria brizantha	..	E. Africa	0·208	0·0386	0·0342	9·75
Urochloa mosambicensis	..	Australia	0·178	0·0439	0·0274	9·19
Cenchrus ciliaris	Anjan	Australia	0·297	0·0318	0·0408	14·75
Panicum maximum	Guinea grass	Australia	0·209	0·0247	0·0289	9·00
Hyparrhenia rufa	..	Brazil	0·182	0·0199	0·0339	9·00
Brachiaria mutica	Para grass	India	0·299	[0·0087	0·0429	15·75
Phalaris tuberosa	..	India	0·08	0·0314	0·07	16·06
Phalaris canariensis	..	India	0·14	[0·0236	0·032	7·37
Lolium perenne	Short rotation rye grass	India	0·21	[0·024	0.0995	20·00
Dichanthium annulatum	Palwan	India	0·27	[0·027	0·039	10·86
Cortadenia argentina	..	India	0·09	[0·021	0·0235	5·81

Methionine

Methionine content of all the foreign grasses studied here, is found to be fairly good as compared to other grasses. Among the foreign ones the *Cenchrus ciliaris* (Australia) has got the highest content (0·297 per cent), while *Setaria sphacelata* (E. Africa) has the lowest content (0·153 per cent). Among the Indian ones, the highest value of 0·299 per cent obtained by Para grass (sewage area) agrees quite well with that of the foreign ones but the lowest value is only 0·08 per cent obtained by *Phalaris tuberosa*. Thus the variation among the foreign ones is not so much as in the case of Indian ones. As compared to the cystine and tryptophane content of these grasses, methionine content is sufficiently high.

Cystine

Cystine content is the poorest of all these amino acids studied here. Its content seems to be higher in the foreign grasses as compared to Indian ones. All the grasses contain varying amount of this amino acid.

Tryptophane

All the grasses differ considerably in this content. Indian grasses vary from 0·035 per cent (*Cartadenia argentina*) to 0·0995 per cent (short rotation rye grass) while the foreign ones vary from 0·0203 per cent (*Setaria sphacelata*, E. Africa) to 0·0408 per cent (*Cenchrus ciliaris*, Australia). The foreign ones appear to be poorer in this constituent.

Protein

Excepting one grass, *Cenchrus ciliaris* (Australia) which contains 14·75 per cent of protein, all the other foreign grasses appear to contain lower percentage of protein ranging from 7·31 per cent (*Setaria sphacelata*, E. Africa) to 9·75 per cent (*Brachiaria brizantha*, E. Africa). The Indian grasses contain varying amount of protein ranging from 5·8 per cent to 20·0 per cent (rye grass). It is notable that some other grasses, *Phalaris tuberosa* and Para grass are also quite high in protein content.

Correlation between the different amino acids of the grasses studied

Correlation between the following pairs of constituents were studied statistically and the results are given below:

Constituents	Correlation Coefficient (r)
Methionine and cystine	—0·8397 Significant
Methionine and tryptophane	+0·7845 Significant
Methionine and protein	+0·1114 Not significant
Cystine and protein	—0·0615 Not significant
Tryptophane and protein	+0·8887 Significant
Cystine and tryptophane	—0·0340 Not significant

The relationship between methionine-cystine, methionine-tryptophane and protein-tryptophane is found to be highly significant though in the first pair, i.e. methionine-cystine, the correlation is negative while in the other two pairs, it is positive. The other pairs do not show any significant correlation.

Summary

1. Twelve legumes and twelve grasses were analysed for their methionine, cystine and tryptophane contents by the microbiological method.

2. Autoclaving for one hour and three hours was found to be adequate for the optimum release of methionine and cystine respectively from the legumes and grass proteins.

3. Legumes and grasses studied here were low in the content of cystine and tryptophane as compared to methionine. Cystine was the poorest.

4. Different legumes and grasses differed considerably among themselves in these amino acids.

5. Some foreign grasses grown on Indian soil, were slightly better in their methionine and cystine content when compared to the Indian ones but in case of tryptophane, the Indian grasses were found to contain higher content than the foreign ones.

6. Protein content of legumes and grasses varied considerably ranging from 12·81 to 26·50 per cent and from 5·8 to 20·0 per cent respectively.

7. In the case of legumes, the relationship between protein-methionine and protein-tryptophane was significant and positive, while in the case of grasses, the relationship between methionine-tryptophane, protein-tryptophane and methionine-cystine was significant and positive, the last being negatively significant.

ACKNOWLEDGMENT

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NICOTINIC ACID CONTENT OF WHEAT AS INFLUENCED BY VARIETY AND LOCALITY

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WHEAT is an important source of nicotinic acid in the diet of the wheat eating population in our country. The composition of wheat is affected by a number of factors such as variety, soil, climate, fertilizers, etc. [Hunt, 1927 ; Hunt *et al.*, 1941 ; Nordgren *et al.*, 1941 ; McElroy, 1948 ; McElroy *et al.*, 1948 ; Harris and Banasik, 1952]. The wide diversity of soil and climate, under which wheat is grown in India, has led to study the influence of locality and variety on the contents of nicotinic acid in wheat. The variation in composition of this cereal has been mostly studied with reference to protein. Only recently, attention has been paid to B-vitamins, of which nicotinic acid has been least studied.

Das *et al.*, [1954], by analysing 12 varieties of Indian wheats grown at I.A.R.I. New Delhi, have shown that nicotinic acid content in wheat varies considerably from variety to variety. This has been further confirmed by the results of the study of 20 important varieties of wheat grown both at New Delhi and Pusa, Bihar.

The object of the present study was twofold : (*a*) to study the variation in the nicotinic acid content of the same variety of wheat grown in different localities and (*b*) to study the variation in the nicotinic acid content of different varieties of wheat grown under comparable conditions.

Material and Methods

(*a*) For the first part of the study, two important varieties of wheat, *NP 52* and *C 591* were collected during 1951-52 from the wheat growing zones of different States of India through the courtesy of the Directors of Agriculture of the respective States. The States and the places from where the samples were collected are given along with the description of the soils of those regions in Tables I and III.

(*b*) For the other part of the study, 20 varieties of wheat grown at the Division of Botany at New Delhi and its Sub-station at Pusa, Bihar were selected.

The sampling of the wheat grains was done in the usual way [Das *et al.*, 1954] and nicotinic acid was estimated by the method developed by Chaudhuri [1951*a*, 1951*b*] and standardised in this laboratory [Prasad *et al.*, 1953].

Results and discussion

Effect of locality on the nicotinic acid in wheat

The wheat NP 52

Fifteen samples of this wheat were obtained from different places (Table I). Eight of these samples were from alluvial soil zone (of which five were calcareous),

four were from black soil area, and remaining three from the red and yellow soil zone. The variation in the nicotinic acid content is discussed below.

TABLE I

Moisture, weight of 100 grains, and nicotinic acid content of wheat (NP 52) from different localities

State	Place	Soil group	Moisture (per cent)	Weight of 100 grains (gm.)	Nicotinic acid (m.g./g.)
				(On oven-dry basis)	
Delhi	I.A.R.I.	Alluvium	7·9	2·6312	69·1
U. P.	Banaras	do.	9·2	3·5435	49·3
Bihar	Pusa	do. (Calc.)*	8·3	3·0811	58·8
	Monghyr	do. (Calc.)	10·4	3·3470	51·2
	Siwan (Saran)	do. (Calc.)	9·9	2·9005	65·5
	Champaran	do. (Calc.)	12·1	3·1814	64·2
	Chapra	do. (Calc.)	11·4	2·2005	46·6
	Purnea	do. (Calc.)	10·4	2·3360	64·5
	Mean		9·95	2·9027	58·65
				±0·1693	±3·02
M. P.	Harsud	Black	11·5	3·7360	47·8
	Morshi	do.	9·0	4·1362	45·7
	Akola	do.	10·9	3·0980	39·3
	Chindwara	do.	8·5	3·4895	53·0
	Mean		9·98	3·6149	46·45
				±0·2178	±2·83
M. P.	Drug	Red and Yellow	8·9	3·1853	48·8
	Waraseoni	do.	11·4	3·3765	51·4
	Sindhwahi	do.	8·3	3·3290	40·7
	Mean		9·53	3·2969 ±0·0575	46·97 ±3·22

*Calcareous

Nicotinic acid. The nicotinic acid content in these samples varies from 39·3 to 69·1μg./g. The wheats from the alluvial soil zone were markedly higher in their content of nicotinic acid as compared to those from the other two groups of soil (black and red) studied here whereas no such difference was found in the samples from the latter two groups of soil (i.e. black and red). Table II shows the results of the tests of significance for the variation in the nicotinic acid content amongst the wheats from the three soil groups.

TABLE II

Nicotinic acid content of wheat in different soil groups

Soil group	Average nicotinic acid (μg./g.)	Difference	't'
Alluvial	58·65±3·02	(All. and black) +12·20	2·95*
Black	46·45±2·83	(All. and red) +11·68	2·65*
Red	46·97±3·22	(Black and red) —0·52	—0·10

*Significant at 5 per cent level.

It will be seen from Table II that the differences in the average nicotinic acid content between (i) alluvial and black, and (ii) alluvial and red were significant at 5 per cent level of significance and that between black and red was not significant. Thus alluvial soil was significantly better than the black and red (yellow) soils with respect to nicotinic acid.

McElroy and Simonson [1948] were unable to find any relationship between the nicotinic acid content and the nature of soil although variations due to season and locality were observed. Hunt *et al.* [1950], found that liming the soil in a five-year rotation experiment increased the nicotinic acid content of wheat, but the samples in this case from the calcareous soils did not show any such difference.

Weight of 100 grains. The weight of 100 grains varied from 2·2005 to 4·1382 gm. the variation being observed in each soil zone also. The wheat grain grown on heavier textured soil, such as black soil, was more in weight than those in other soil zones. The statistical analysis for the variation of grain weight amongst different soil groups is given below :

Soil group	Average weight of 100 grains (gm.)	Difference	't'
Alluvial	2·9027±0·1693	(Alluvial and black) —0·7122	3·04*
Black	3·6149±0·2178	(Alluvial and red) —0·3942	1·9
Red	3·2969±0·0575	(Black and red) ±0·3280	1·23

*Significant at 5 per cent level.

The superiority of black soils over alluvial soils is just the reverse of that in the case of nicotinic acid.

Correlation coefficients between nicotinic acid and grain weight was not statistically significant.

The wheat C 591

The total number of samples of wheat of this variety was eleven, seven from alluvial soil zone and the other four from the black soil area. Data on nicotinic acid, moisture, and grain weight are given in Table III. The average moisture content in the two groups was practically similar.

TABLE III

Moisture, weight of 100 grains, and nicotinic acid of wheat (C 591) from different localities

States	Place	Soil group	Moisture (per cent)	Weight of 100 grains (gm.)	Nicotinic acid (μg./g.)
				(On oven dry basis)	
Punjab	Jullundur	Alluvium	9·5	4·3216	59·7
Delhi	I.A.R.I.	do.	11·1	4·0808	71·9
U. P.	Nagina	do.	9·9	3·5895	50·5
	Attara	do.	10·0	4·3843	49·8
	Aligarh	do.	9·2	3·7454	56·7
M. B.	Gwalior	do.	9·7	4·1417	51·3
	Bagwai	do.	9·5	3·4149	48·3
	Mean		9·84	3·9540	55·46
				±0·1413	±3·14
M. B.	Khargaon	Blaek	10·0	3·8839	45·6
	Indore	do.	11·8	3·6407	50·1
	Bhilsa	do.	10·4	3·8924	50·3
	Manasa	do.	9·1	4·3100	47·2
	Mean		10·33	3·9318	48·3
				±0·1290	±1·15

Nicotinic acid. In these wheats, the minimum content of nicotinic acid was found in the sample from Kharagon—a black soil area whereas maximum content was found in the sample from Delhi—an alluvial soil zone. With respect to nicotinic acid, this variety resembles the variety *NP 52* in that the wheats grown in alluvial soil areas have higher concentration of nicotinic acid than those grown in black soil zones. Tests of significance between the two groups show the 't' value to be 2·14. This value is very near the theoretical value for being statistically significant. Thus the difference between the two groups may be taken to be statistically significant.

Weight of 100 grains. The weight of 100 grains varied from 3·4449 to 4·3843 gm. and the averages for the two soil groups were practically the same.

Different varieties of wheat grown under comparable condition

As stated earlier, the object of this part of the investigation was to study the varietal difference in the content of nicotinic acid and weight of 100 grains in different varieties of wheat grown at the same place. This was an extension of the earlier study by selecting increased number of varieties grown at two different places, viz., Pusa (Bihar) and Delhi. The data are given in Table IV.

TABLE IV

Moisture, weight of grain, and nicotinic acid in different varieties of wheat grown at I.A.R.I. and Pusa

Variety	Place	Moisture (per cent)	Weight of 100 grains (gm.)	Nicotinic acid (μg./g.) (On oven-dry basis)
NP 4	I.A.R.I.	8·7	4·2289	51·0
	Pusa	8·9	3·2492	54·7
NP12	I.A.R.I.	9·3	3·3011	66·3
	Pusa	9·8	2·3167	62·1
NP 52	I.A.R.I.	7·9	2·6312	69·1
	Pusa	8·3	3·0811	58·3
NP 710	I.A.R.I.	9·5	3·9946	48·2
	Pusa	8·3	3·8804	50·3
NP 111	I.A.R.I.	9·0	4·1066	55·1
	Pusa	9·6	3·1330	53·4
NP 120	I.A.R.I.	9·0	2·8030	53·7
	Pusa	9·7	2·7146	56·0

TABLE IV—(contd.)

Moisture, weight of grain, and nicotinic acid in different varieties of wheat grown at I.A.R.I. and Pusa

Variety	Place	Moisture Per cent	Weight of 100 grains (gm.)	Nicotinic acid (μg./g.) (On oven-dry basis)
NP 165	I.A.R.I.	9·5	3·8730	53·0
	Pusa	9·9	3·1978	63·4
NP 715	I.A.R.I.	9·6	3·3812	54·6
	Pusa	9·5	4·2301	45·6
NP 718	I.A.R.I.	9·2	4·0717	45·6
	Pusa	9·9	3·5460	50·8
NP 720	I.A.R.I.	9·4	4·1101	51·7
	Pusa	9·8	3·4897	49·9
NP 721	I.A.R.I.	9·4	3·5142	51·7
	Pusa	10·1	3·4786	57·7
NP 737	I.A.R.I.	9·3	4·3789	50·9
	Pusa	10·6	4·0689	71·6
NP 760	I.A.R.I.	9·6	4·1205	56·1
	Pusa	10·4	4·1963	53·7
NP 761	I.A.R.I.	10·0	3·3504	49·0
	Pusa	10·5	3·6139	50·8
NP 762	I.A.R.I.	9·7	4·2685	57·9
	Pusa	10·4	4·6271	45·3
NP 764	I.A.R.I.	10·1	3·4131	57·5
	Pusa	11·0	4·2591	56·4
NP 775	I.A.R.I.	10·0	4·0368	55·7
	Pusa	10·7	4·2418	68·3
NP 80-5	I.A.R.I.	10·8	3·4720	58·4
	Pusa	10·5	2·9376	68·4
NP 745	I.A.R.I.	10·0	3·4450	64·1
	Pusa	10·6	3·0662	59·7
NP 758	I.A.R.I.	9·8	4·0333	54·4
	Pusa	10·3	3·8356	54·1

TABLE V

Average weight of 100 grains and nicotinic acid for varieties

Variety	Weight of 100 grains (gm.)	Nicotinic acid (μg./g.)
		(On oven-dry basis
NP 4	3·7391	52·85
NP 12	2·8089	64·20
NP 52	2·8562	63·70
NP 710	3·9375	49·25
NP 111	3·6198	56·75
NP 120	2·7588	54·85
NP 165	3·5354	58·20
NP 715	3·8057	50·10
NP 718	3·8089	48·20
NP 720	3·7999	50·80
NP 721	3·4964	54·70
NP 737	4·2239	61·25
NP 760	4·1584	54·90
NP 761	3·4822	49·90
NP 762	4·4478	51·60
NP 764	3·8361	56·95
NP 775	4·1393	62·00
NP 80-5	3·2098	63·40
NP 745	3·2556	61·90
NP 758	3·9345	54·25
$S.E_m$	±0·2784	±4·06

'F' test not significant

Nicotinic acid. The nicotinic acid content of the wheat varieties grown at I.A.R.I. (Delhi) varied from 45·6 μg./g. (NP 718) to 69·1 μg./g. (NP 52). In the previous study also, the variety NP 718 had the maximum content of nicotinic acid in that

group [Das *et al.*, 1954]. Of course, the individual figures were a little higher than those in the previous case. The range in the content of nicotinic acid of the samples from Pusa was from 45·3 μg./g. (NP 762) to 71·6 μg./g. (NP 737).

The varietal differences were statistically examined against the interaction of place and varieties as error. The results of the statistical analysis are given in Tables V and VI. The difference between the two places was not significant. Average varietal differences were also not significant. Varietal difference at a place could not be tested statistically as replicates were not available. The variation in the content of nicotinic acid amongst the different varieties confirm the earlier observations that this constituent in wheat is greatly influenced by the genetic factors [Burkholder *et al.*, 1944 ; Ditzler *et al.*, 1948 ; Teply, Strong, and Elvehjem, 1942 ; Carrol and Peng, 1951]. The variation in this constituent at the two localities was not regular. In 11 varieties, nicotinic acid was higher insamples from Pusa whereas in others it was reverse.

TABLE VI

Average weight of 100 grains and nicotinic acid for places

Place	Weight of 100 grains (gm.)	Nicotinic acid (μg./g.)
I.A.R.I.	3·7267	55·20
Pusa	3·5587	56·78
$S.E_m$	±0·8803	±1·28

'F' test not significant

Weight of 100 grains. In this case as well, varieties or places did not show any significant differences amongst themselves. Fifteen varieties of wheat grown at Pusa had, however, a higher grain weight as compared to the corresponding ones at Delhi. The difference in certain cases was quite marked while in other cases, it was negligible. At Delhi, *NP 52* had the least content of moisture as well as grain weight. Nicotinic acid was negatively correlated with the weight of 100 grains at both the places, being statistically significant at 5 per cent level at Delhi, but not at Pusa.

SUMMARY

The variations in the content of nicotinic acid and grain weight of two important varieties of Indian wheat (*NP 52* and *C 591*) grown at different localities and also of 20 different varieties of Indian wheat grown at Delhi and Pusa were studied.

For the same variety of wheat, nicotinic acid content was higher in the grains raised in alluvial soil as compared to those raised in black and red soil zones. The difference was statistically significant. In *NP 52*, the average grain weight was higher in the black soil group.

There existed a varietal difference in the content of nicotinic acid and grain weight of the varieties grown at the same place and a negative correlation between the nicotinic acid content and grain weight.

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ANTIOXIDANTS FOR EDIBLE OILS AND FATS FROM SEEDS OF INDIGENOUS *MYRISTICA* SPECIES

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SEEDS from many species of *Myristica* genus have been reported to contain large amounts of resinous matter and unsaponifiables, many of which are crystalline. Five per cent of a crystalline substance of formula $C_{18}H_{22}O_5$ and smaller quantities of other crystalline substances are present in the oil from the seeds of *Myristica fragarans* (*officianalis*) [Power and Salway, 1907]. Seed kernels of *M. malabarica* contains 41 per cent of fats and resins and the mace 64 per cent [Spaeth, quoted by Lewkowitsch, 1922]; carbon tetrachloride extract of the fat contained about 57 per cent of fat and 43 per cent resins which gave a red colour with alkali [Hilditch and Collins, 1930]. Seeds of *Pycnanthus combo* gave 54 per cent of a hard fat of iodine value 65 to petroleum ether; the refined fat showed iodine value of 34 and hence large amounts of acidic resins of high unsaturation were present in the crude fat [Imperial Institute, 1908]: the mace yielded 57 per cent extract which developed deep violet colour with alkalies. Riemer and Will [1888] reported that fat from *Myristica surinamensis* contained a caoutchoutch like resin. Lewkowitsch [1908] and Bolton and Hewer [1917] found that *Myristica bicuhyba* fat contained 5-6 per cent of resinous matter which cannot be removed from the fat. Jamieson *et al.*, [1921] found that fat from *M. otoba* contained 20 per cent of unsaponifiables of which about half consisted of two crystalline substances, otobite and iso-otobite. Pillai and Nair [1945] isolated a phytosterol m.p. 122°C, and a phenol carboxylic acid m.p. 98°C from *M. attenuata*. Seed kernels of *M. canarica* contained about 65 per cent of a light brown crystalline fat, the colour being due to presence of resinous impurities [Lewkowitsch, 1922].

There are five indigenous species of *Myristica* in India, namely, *M. malabarica*, *M. canarica*, *M. attenuata*, *M. beddomei*, and *M. magnifica*. They grow wild extensively on the Western Ghats and the seeds are at present not utilised, excepting probably a small amount of *M. canarica* seeds which is exported [Lewkowitsch, 1922]. Kartha has been studying the chemical constituents of these indigenous *Myristica* seeds from 1948 with a view to commercial utilisation of this extensive raw material source. He has made the following observations:

(1) *M. canarica* seed kernels contained about 3-4 per cent of a crystalline phenolic body, m.p. 208°C which gave crystalline acetyl derivative and methyl ether [Kartha, 1948]. When the seed was extracted with carbon tetrachloride, the substance came along with the fat, but when the fat is expressed most of this material remains in the press cake

from which it can be extracted with alcohol. The fat contained dark brown resinous matter in the free acidic and neutral portions; the resins could not be separated from the fat without hydrolysis.

(2) *M. malabarica* seed kernels contained 43-45 per cent of extractives consisting of fats and resins. Benzene extracted about 15 per cent of crude fat and 12 per cent of resins (total 27 per cent). Subsequent extraction with alcohol brought out another 16-17 per cent of resins [Kartha, 1948]. The benzene extract was light yellow in colour; the alcohol extract was orange-red. The neutral fat came to about 12 per cent of the seeds [Kartha, 1954], the rest of the benzene extract and the whole of the alcohol extract consisted of acidic matter. On concentrating and cooling the benzene extract, a substance m.p. 120-122°C crystallised out [Kartha, 1948]. This dissolved in sodium carbonate solution with a deep red colour, but gave alkali insoluble substances on treatment with acetic anhydride, or with dimethyl sulphate and aqueous potassium hydroxide, and hence was phenolic in character. The benzene insoluble alcohol soluble fraction could not be crystallised but gave the same phenolic reactions as the above crystalline substance.

The evidence that the crystalline substance from *M. canarica* and most of the resins from *M. malabarica* were phenolic in nature indicated the possible use of these as antioxidants for oils and fats, for a large number of synthetic and natural phenolic substances have been found to show good antioxidant activity for oils and fats, for example gossypol [Mattill, 1931; Royce, 1933; Clark, 1927]; thyroxin [De Caro, 1933]; gum guaiac [Grettie, 1933]; nor-dihydro-guiaretic acid [Fonyo, 1946]; and nor-conidendrin [Fisher, Kyame and Bickford, 1947]. Preliminary tests using hydrogenated fats had shown that all these phenolic substances from indigenous *Myristica* species showed antioxidant activity. The present article records the results of a more detailed study of the antioxidant properties of these substances, i.e. Phenolic substances from *M. canarica* and *M. attenuata* seeds and *M. malabarica* mace.

The benzene or petroleum ether extracts of *M. canarica* and *M. attenuata* seed are almost black in colour. These extracts as such and after separation of crystalline materials showed antioxidant properties, but the colour imparted even at very low concentrations is heavy and unattractive and hence they cannot be used for any type of fat where light colour is desired. Dark coloured resins are present in both the acidic and neutral portions and cannot be removed by any simple procedure. The crystalline phenol m.p. 208°C from *M. canarica*, the neutral crystalline material m.p. 122°C and phenolic substance m.p. 98°C from *M. attenuata* (the material prepared in the laboratory showed m.p. 84°C) were also tested for their activity at small concentrations. The incubation method was used, 10 cc. of fat being incubated in 4 oz. wide mouth glass bottles with ground glass stopper at 96°C and 60°C, and the samples examined periodically for organoleptic rancidity, which when detected is confirmed by peroxide value determinations. Peroxide values (millimols. per kilogram of fat) of 10, 20, 20 and 40 were taken to indicate

end of induction period for *vanaspati*, lard, *ghee* and groundnut oil respectively. The results for the above three crystalline substances are given in Table I; they increase the induction period of *vanaspati* by a maximum of about 50 hours at 96°C. This activity is too low for the substances to be of any practical use. The ethyl acetate extract of *M. fragrans* examined in the same way (Table I) showed absolutely no activity.

TABLE I

Stabilities of fats and oils after treatment with extracts from various Myristica *seeds*

Nature of extract or added substance	Dosage per cent	Blank fat used	Stability at 96°C hrs.	
			Blank fat	Experiment
Phenol m.p. 207°C from *M. canarica*	(*a*) 0·03	*Vanaspati*	75	116
	(*b*) 0·06	do.	75	116
Phenol m.p. 85°C from *M. attenuata*	0·05	do.	27	72
Cryst. matter m.p. 122°C from *M. attenuata*	0·05	do.	27	82
Phenol m.p. 85°C from *M. attenuata*	(*a*) 0·03	do.	70	110
	(*b*) 0·02	do.	70	105
	(*c*) 0·01	do.	70	120
Petrol insoluble part of benzene extract from *M. malabarica*	(*a*) 0·06	do.	70	600
	(*b*) 0·03	do.	70	600
Ethyl acetate extract from *M. malabarica Mace*	(*a*) 0·06	Groundnut oil	26	56
	(*b*) 0·03	do.	26	47
Ethyl acetate extract from *M. fragrans* seeds	(*a*) 0·10	do.	36	36
	(*b*) 0·05	do.	36	36

The mace from *M. malabarica* is available commercially though it is somewhat costly because of its use as an *Ayurvedic* drug. The mace contains about 65 per cent extractives soluble in hot ethyl acetate, of which some 25 per cent consists of fats; the resins thus come to only about 35-40 per cent of the weight of the material. Preliminary tests show that the ethyl acetate extract of the mace shows good antioxidant properties (Table I). The extract is reddish in colour and contains only relatively small amounts of oil-insoluble matter for it leaves only traces of insoluble matter when incorporated into *vanaspati*, lard or *ghee*. Weight for weight the resin from the mace is somewhat less active than the resins from the seeds to be subsequently described, but it is possible that inactive material can be removed from the mace resin. Work on these lines is in progress.

Phenolic resins from M. malabarica *seeds*

The phenolic resins from *M. malabarica* seeds have given results which are quite encouraging. The extracts in this case are light coloured and can be directly incorporated into the fats to be stabilised with very little further processing. The activity of the resins in the benzene extract at small concentrations was first studied;

for this the solvent was removed from the benzene extract by distillation and the residue refluxed with excess of petroleum ether b.p. 70-90°C, cooled and petroleum ether solution decanted off. After two treatments like this, the almost colourless residue was dissolved in alcohol and made up to a known volume and the weight of residue in 1 cc. of solution determined. The resin is incorporated into fats by adding measured quantity of this solution to weighed amounts of fat and removing the solvent in a vacuum in a current of air. At 0·03 and 0·06 per cent concentration in *vanaspati* the resin imparted only very light colour and there was only a trace of oil-insoluble matter. The results obtained at these doses in *vanaspati* (Table I) show high antioxidant activity. The activity of this resin at 0·005, 0·01 and 0·02 per cent concentrations in *vanaspati* at 96°C and 60°C are given in Table II.

TABLE II

Stabilities of fats and oils after treatment with different extracts from Myristica malabarica *seeds*

Details of extract	Dosage as extract	Dosage as resin	Blank fat used	Stabilities at 96°C hrs.		Stability at 60°C days	
				Blank	Experiment	Blank	Experiment
Petrol insoluble part of benzene extract	(*a*) 0·005	..	*Vanaspati*	75	180	45	125
	(*b*) 0·01	..	do.	75	360	45	>220
	(*c*) 0·02	..	do.	75	360	..	..
Total benzene extract	(*a*) 0·02	0·01	do.	75	320	45	>220
	(*b*) 0·04	0·02	do.	75	320	45	>220
Total ethyl acetate extract	(*a*) 0·015	0·01	do.	90	380	45	>220
	(*b*) 0·030	0·02	do.	90	380	45	>220
Benzene insoluble-alcohol soluble resin as such	(*a*) 0·01	..	do.	50	200	..	..
	(*b*) 0·02	..	do.	50	200	..	..
	(*c*) 0·03	..	do.	50	180	..	..
Benzene insoluble-alcohol soluble resins after washing with hot water	(*a*) 0·01	..	do.	90	290	50	>220
	(*b*) 0·02	..	do.	90	290	50	>220
Total ethyl acetate extract	(*a*) 0·015	0·01	Cow's ghee	7	15	3	6
	(*b*) 0·030	0·02	do.	7	45	3	44
Total ethyl acetate extract	(*a*) 0·015	0·01	Lard	8	26	3	18
	(*b*) 0·030	0·02	do.	8	48	3	50
Total ethyl acetate extract	(*a*) 0·015	0·01	Groundnut Oil	17	32	7	17
	(*b*) 0·030	0·02	do.	17	34	7	17

As already mentioned extraction of benzene extracted seeds with alcohol gave 16-17 per cent of reddish alcohol soluble resins; this was incorporated into a *vanaspati* (alcoholic solution used) as before at 0·01, 0·02 and 0·03 per cent concentrations and the results of stability tests at 96°C are given in Table II. A sample of the same resin after repeated washing with hot water to remove water soluble extractives was incorporated by the same technique into *vanaspati* at 0·01

and 0·02 per cent concentrations and stabilities measured at 96°C and 60°C (Table II). The results show that the water and benzene insoluble resins possess good antioxidant activity. Whether the same antioxidant resin is concerned in both the benzene and alcohol extracts is yet to be studied. The benzene soluble resins gave only small traces of oil-insoluble material, but the benzene insoluble resins gave larger amounts of oil-insoluble residue which separated as a blackish precipitate ; no attempt was made in these preliminary studies to remove this insoluble material. However, though the alcohol extract itself was coloured, it imparted only a light yellow colour to the oil on incorporation, the bulk of the colouring matter separating out with the insoluble matter. The benzene insoluble-alcohol soluble resin gave maximum protection at about 0·01 per cent and it was comparable at this concentration to the benzene soluble resins at the same dose. Hence a substantial part of the antioxidants in the seed is present as benzene insoluble-alcohol soluble resins. On weight basis the benzene extracted resins form about 12-13 per cent of the kernels whereas the benzene insoluble-alcohol soluble fraction amounts to about 16-17 per cent. Hence the economic utilisation of the seeds should include working up both fractions of the resins, working them up together in a single operation will be more economical.

The benzene extract contains only fat in addition to the petroleum ether insoluble resins and hence incorporation of the total benzene extract as such should give practically the same activity as when the pure resin is used. To confirm this the benzene extract was directly incorporated in *vanaspati* at 0·01 and 0·02 per cent concentrations based on its resin content and stabilities of the fats measured at 96°C and 60°C. The results (Table II) show that there is no necessity to remove the petroleum ether soluble portions from the benzene extract for using the latter as antioxidants. Subsequently, attempts were made to find out a solvent which will extract all the fats and resins in one stage and it has been found that the total quantity of extractives brought out by benzene followed by alcohol is removed in a single stage extraction by ethyl acetate or by an azeotropic mixture of alcohol and benzene, or by alcohol alone. When extraction is done with alcohol, the fat is removed to a large extent in suspension and extraction takes too long time. To confirm that the total extractives thus obtained possess the antioxidant activity unimpaired, the ethyl acetate extract of the seeds was incorporated as such into the *vanaspati* at 0·01 and 0·02 per cent concentrations on the resin basis and the stabilities of the samples determined at 960 and 60°C ; no attempt was made to filter off the small amount of insoluble matter. The experiments were repeated with specimens of *ghee*, lard and refined groundnut oil. The results (Table II) show that the total extractives from *M. malabarica* seeds can be used as antioxidants directly.

It has been mentioned already that the resin extracts give small amounts of oil-insoluble residue which has of course to be removed by filtration in practical application. On a factory scale adding an ethyl acetate or alcohol benzene extract to the whole of the fat to be stabilised and then filtering off the insoluble residue

will not be convenient. For practical application the oil-soluble antioxidants should be isolated in a pure state so that it does not give any insoluble residue when added to the fat in bulk or an oil concentrate of the antioxidant should be prepared. The latter alternative is simpler and hence attempts were made to ascertain the maximum solubility of the antioxidant resins in oil when solution is effected by extracting the total extractives with oil. For this a known amount of the total extractives in ethyl acetate or alcohol solution is added to *vanaspati* and solvent removed by bubbling air through it in a vacuum at 100°C. The weights of the extractives were taken such that the resins present came to 2 per cent and 4 per cent on the basis of fat in the two experiments. After removal of solvent, the insoluble resin is allowed to settle down for a few hours and the supernatant clear oil is filtered off as much as possible. The residual resin left in the flask and filter paper is dissolved by treatment with about 50 cc. boiling alcohol and *vanaspati* added to it in double the quantity used in the first extraction in both cases and the oil soluble portion extracted as before and the extract filtered. The second extracts from both the 2 per cent and 4 per cent experiments were added in 1 per cent and 3 per cent concentrations to lard and the increase in stabilities measured ; the results are given in Table III. The second extract from the 2 per cent experiment showed little activity, the increase in stability using 3 per cent of this is only a small fraction of the stability imparted by 0·5 per cent of the first extract in the same experiment. The second extract from the 4 per cent experiment, however, showed appreciable residual activity. These results show that the reddish components in the resin show little, if any antioxidant activity, apart from their insolubility in oil and that the active antioxidants in the resin can be extracted almost completely by a single extraction with oil if 100 parts of oil are used for every 2 parts of resin. When smaller amounts of the oil than the above are used for the first extraction, larger

TABLE III

Extraction of antioxidants from M. malabarica *seed resins with oil*

No.	Details of extract	Dosage	Blank fat	Stability of blank fat		Stability experiment	
				Hrs. at 96°C	Days at 60°C	Hrs. at 96°C	Days at 60°C
		Per cent					
1	2 parts extracted with 100 parts *vanaspati* : first extract	0·5	Lard	9	4	39	26
		1·0	,,	9	4	57	45
		1·5	,,	9	4	67	...
		3	,,	9	4	67	>50
		0·5	Ghee	30	17	69	>50
		1·0	,,	30	17	300	>50
		1·5	,,	30	17	250	>50
2	Residue from above extracted with 200 parts oil (i.e. second extract)	1	Lard	10	4	8	6
		3	,,	10	4	12	12
3	4 parts extracted with 100 parts oil and residue re-extracted with 200 parts (i.e. second extract)	1	,,	10	4	11	6
		3	,,	10	4	30	33

proportions of the antioxidants remain behind in the insoluble residue. If re-extraction of the residue is attempted, then it will contain too little of antioxidants for direct use, and will have to be further enriched by utilising it for the first extraction in a second batch. The activity thus recovered may be small and can be neglected in a large scale working when 100 parts of oil are used for 2 parts of resin in the first extraction. That a powerful oil concentrate of the antioxidant is obtained by this method is proved by the large increase in stability imparted when the concentrate from the 2 per cent experiment is added at 0·5, 1·0 and 1·5 per cent concentrations to specimens of lard and *ghee* (Table III).

Proportions of antioxidant resins present in M. malabarica *seed*

The portion of the resin insoluble in fat was estimated to get an idea of the percentage of oil soluble antioxidants present. For this an alcoholic solution containing 2 parts of resin was mixed with 100 parts of *vanaspati* and solvent removed in a current of air in a vacuum. After allowing to settle, the fat was filtered off and residual fat in flask and filter paper removed by repeated washing with petroleum ether b.p. 70-90°C and insoluble resin isolated with hot alcohol. This comes only to 20 per cent of the original resin taken. A repetition of the same procedure, using 100 parts of fat for 2 parts of the insoluble residue decreased the weight of the insoluble resin from 20 per cent to about 18-19 per cent, showing that extraction of all oil-soluble material is practically complete in one stage when 100 parts of oil are used for 2 parts resin. Thus, of the water insoluble extract of the seeds, which amounts to about 41-43 per cent, about 6-7 per cent consists of oil insoluble resins, about 13-14 per cent of fats and fatty acids, and the balance of 21-22 per cent consists of the antioxidant resins. The most predominant constituent of *M. malabarica* seed is hence the antioxidant resin, this amounting to about 50 per cent of the total extractives, and about a quarter of the weight of the seed itself.

Comparative activity of M. malabarica *seed resins against commercially available antioxidants*

Butylated Hydroxy Toluene (B.H.T.) is one of the best antioxidants commercially available for use with edible fats and some comparative tests were done using 0·02 per cent of B.H.T. on the one hand and 0·016 per cent of oil soluble resins of *M. malabarica* seeds on the other (this corresponds to 0·02 per cent of total resins). The base fats used were lard, *ghee* and refined groundnut oil and some of the experiments are still in progress. The results already obtained (Table IV) show that the present antioxidant does not show a lower degree of activity than B.H.T. in any case studied ; frequently it shows a higher degree of activity than the B.H.T.

Experiments are in progress to isolate the pure chemical compounds from the different resin fractions and study their properties and chemical structure. The total oil-soluble antioxidants can be recovered from the oil concentrate described earlier by refluxing with small volumes of alcohol ; this is also being studied in detail. These results will be communicated later as also the results of feeding tests to determine whether the resins are toxic or not.

TABLE IV

Comparative stabilities of fats treated with M. malabarica *resin and butylated hydroxytoluene*

No.	Blank fat used	Stability of Blank		Antioxidant used	Dose	Stabilities of Experiment fats	
		96°C hrs.	60°C days			Hrs. at 96°C	Days at 60°C
1	Refined G. N. Oil	26	..	B.H.T.	0·01	39	..
					0·02	39	..
2	Refined G. N. Oil	36	13	B.H.T.	0·02	56	29
		36	13	M. M. seed-oil-soluble resin	0·016	62	29
3	Lard I	12	4	B.H.T.	0·02	46	33
		12	4	M. M. seed-oil-soluble resin	0·016	68	87
4	Lard II	12	8	B.H.T.	0·02	72	36
		12	8	M. M. seed-oil-soluble resin	0·016	100	>120
5	*Ghee*	14	10	B.H.T.	0·02	200	>120
				M. M. seed-oil-soluble resin	0·016	280	>120
				ditto	0·032	500	>120

SUMMARY

Antioxidants are widely used to prevent spoilage of fats, particularly those intended for edible purposes and the entire requirements of India in this respect are at present imported. The antioxidant properties of some phenolic substances derived from seeds of some indigenous *Myristica* species, which may possibly be commercially exploited, are reported in this article.

The crystalline phenolic substances present in *Myristica attenuata* and *M. canarica* showed only slight activity. The phenolic bodies reported in *M. malabarica* seeds by Kartha [1948] showed powerful antioxidant properties; so also the phenolic substances present in *M. malabarica* mace. In the case of *M. malabarica* seeds the oil-soluble antioxidant fraction is a light coloured resin and is present to the extent of 22-24 per cent of the weight of the kernels. A portion of this has been obtained in crystals m.p. 120-22°C. The coloured impurities present in the crude extract of the seeds are readily removed and a light coloured oil concentrate containing about 1·6-2·0 per cent of the resin can be readily prepared; 0·5 per cent of this concentrate corresponding to about 0·008 per cent of the resin is, as a rule, enough to give sufficient stability to *vanaspati*, *ghee* or lard. Comparative tests using butylated hydroxy-toluene (B.H.T.), one of the best edible fat antioxidants commercially available at present, show that the present resin is in most cases more active than the B.H.T.

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THE OCCURRENCE OF β -SITOSTEROL IN THE NUTS OF ARECA CATECHU

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In the course of an investigation on the alkaloidal contents of Indian areca nuts, it has been observed that considerable quantity of steroidal material is isolable from this source. Although extensive studies have been carried out on the alkaloids of areca nuts [Henry 1949] the only reference to the isolation of a sterol from this source has been made by Sho Kuvada and S. Yoshiki [1937]. These workers have characterised the sterol only by its melting point and have not established its identity. Saponification of the fat (which is approximately 10 per cent by weight of the nut) with alcoholic potash afforded the sterol from the nonsaponifiable portion. On purification by chromatography over alumina in benzene solution and subsequent crystallisation from methanol, the sterol melted at 139-140°. In chloroform solution, it showed a specific rotation of −37°. The acetyl derivative prepared in the usual manner, melted at 127–8° and exhibited a specific rotation of −42° in chloroform. The benzoate had m.p. 146°. On admixture with authentic specimens of β-sitosterol and its corresponding derivatives, the sterol from areca nuts and its derivatives showed no depression in melting point.

Experimental

The dehusked and powdered nuts (7 kg.) were extracted continuously with trichlorethylene until the solvent extracted no more material. The combine extracts were then distilled over a waterbath at ordinary pressure. The residual fatty material (300 g.) was completely freed from the solvent, saponified in the cold with 10 per cent methanolic potash and left overnight. It was then diluted with an equal volume of water and extracted with ether. The ether extract after washing with water, was dried and distilled. The residue (3g.) was a brownish, sticky solid. It was dissolved in absolute benzene and chromatographed over a column of alumina. The solid eluted down with more of the same solvent was purified by crystallisation from methanol. It formed colourless plates melting at 140° and showed a specific rotation of −37° (c= 1·2 t, 30°) in chloroform solution. It answered the Salkowski and Libermann-Burchard colour reactions diagnostic of sterols.

Acetate of the sterol. The acetate of the sterol was made by treating the sterol (100 mg.) in pyridine solution (2 ml.) with acetic anhydride (1 ml.) at room temperature (24 hours). Crystallised from methanol, it separated as colourless needles melting at 127-8°. It had a specific rotation of −42° (c=1·2 t, 30°) in chloroform solution.

Benzoate of the sterol. The benzoate of the sterol was prepared by adding benzoyl chloride (10 drops) to the sterol (100 mg.) in dry pyridine solution (2 ml.) and leaving at room temperature for 24 hours. The benzoate on crystallisation from methanol separated as white needles melting at 146°.

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PHYSICO-CHEMICAL CHANGES IN JACK FRUIT SQUASH DURING STORAGE

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(with one Text-figure)

The nature and extent of changes in food products depend to a large extent upon the methods of preservation and the conditions of storage. Changes in *p*H, acidity, sugars, proteins, vitamins, minerals, pectic substances, colour and general quality of several important fruit juices and squashes have been studied in detail by various workers [Wilson, 1928 ; Cruess and co-workers, 1930, 1932 and 1942 ; Nelson *et al.*, 1933 ; Joslyn and Marsh 1936 ; Loeffler, 1941 ; Pederson *et al.*, 1941 ; Moore *et al.*, 1942 (a) & (b) 1944 ; Beattie *et al.*, 1943 ; Tressler *et al.*, 1943 ; Clifcorn and Peterson 1947 ; Greer, 1944 ; Curl *et al.*, 1946 ; Esselen *et al.*, 1946 ; and Pruthi, 1949].

There is, however, no such data available for jack fruit (*Artocarpus integrifolia*) squash, which is a new product [Bhatia, *et al.*, 1946]. It was, therefore, of interest to study in detail the effect of different methods of preservation and storage temperature on *p*H, acidity, reducing and total sugars, ascorbic acid and colour changes.

Material and Methods

Jack fruit available in the local Mysore market, commercial grade crystalline sugar and C. P. grades of citric acid, potassium metabisulphite and sodium benzoate were used for the preparation of squash. Ascorbic acid used for fortifying the squash was of Merck quality. The squash was prepared by the method described by Bhatia, *et al.* [1956]. Three sets of squash of 44°, 52° and 62° Brix and having 17.4 per cent fruit and 1.0 per cent citric acid were prepared. The methods of preservation studied were (i) 350 p.p.m. SO_2 added as potassium metabisulphite, (ii) 200 p.p.m. SO_2 added as potassium metabisulphite, (iii) 0.1 per cent sodium benzoate, (iv) 0.05 per cent sodium benzoate, (v) flash pasteurization at 180-185°F and filling the bottles under aseptic conditions, (it took 4-5 minutes to fill each 12 oz. bottle), (vi) overflow pasteurization at 175°F for 25 minutes, (vii) deaeration twice at room temperature for 15 to 20 minutes each time+350 p.p.m. SO_2 and (viii) deaeration+350 p.p.m. SO_2+packing in nitrogen gas (gas bubbled for about five minutes at a slow rate before crown corking the bottles).

Three levels of fortification by ascorbic acid, e.g. 50, 100 and 150 mg./per cent were tried.

Three storage temperatures, i.e. room temperature (24-30°C), and refrigerated temperature of 2-5°C were employed.

In all the chemical estimations, a representative sample was weighed after mixing well the contents of a single bottle. In order to study variations in individual bottles,

in the beginning of this investigation, determinations of *p*H, acidity and reducing sugars, in six individual bottles were made. This revealed that variation from bottle to bottle was negligible (*p*H 2·93±0·005, acidity 1·01±0·004 and reducing sugars 46·98±0·085). It was, therefore, not considered necessary to analyse more than one bottle in subsequent estimations. To start with, ascorbic acid was estimated by direct titration of the squash in 2 per cent metaphosphoric acid with 2-6 dichlorophenol-indophenol. In the case of samples preserved with SO_2, however, interference due to SO_2 was eliminated by following the procedure of Lugg [1942]. After storage, ascorbic acid was determined by the xylene extraction method of Robinson and Stotz [1945]. Dehydroascorbic acid also was determined in a few cases by the method described by Rubin, Jahns and Bauernfeind [1945]. Reducing and total sugars were determined by the method of Lane and Eynon [1923]. Total titratable acidity was estimated by titrating with standard NaOH. SO_2 was determined by the method of Kirkpatrick [1941], *p*H with Beckman *p*H meter and refractometer solids with a hand refractometer. Colour measurements in yellow, red and blue units were made by using a Lovibond Tintometer. Visual colour gradation of samples was also made according to the following scheme :

Light yellow, I ; yellow, II ; deep yellow, III ; light orange, IV ; orange, V and deep orange, VI.

Organoleptic evaluation was made with the help of a panel of judges selected from the staff of the Institute, the samples being diluted with water to 12·50 brix for tasting.

Experiment

As it was not possible to pack sets of all the different treatments simultaneously and to analyse them during storage, three sets of squashes of manageable size were prepared to study the effect of (*a*) different methods of preservation, (*b*) fortification with ascorbic acid and (*c*) packing under nitrogen. These are detailed in Table I.

Table I

Treatments in sets I, II and III.

Treatment	Set I	Set II	Set III
	52° Brix squash in bottles	52° Brix squash in bottles	52° Brix squash in bottles
1.	350 p.p.m. SO_2	(1) 350 p.p.m. SO_2	1. 350 p.p.m. SO_2
2.	200 p.p.m. SO_2	(2) 350 p.p.m. SO_2+ 100 mg./100 g. ascorbic acid	2. 350 p.p.m. SO_2 + nitrogen
3.	0·1 per cent sodium benzoate	(3) 350 p.p.m. SO_2+ 150 mg./100 g. ascorbic acid	

TABLE I—(contd).

Treatments in sets I, II and III

Treatment	Set I	Set II	Set III
	52° Brix squash in bottles	52° Brix squash in bottles	52° Brix squash in bottles
4.	0·05 per cent sodium benzoare	(4) 0·10 per cent sodium benzoate	
5.	Flash pasteurization	(5) 0·10 per cent sodium benzoate + 100 mg./100 g. ascorbic acid.	
6.	Overflow pasteurization	(6) 0·10 per cent sodium benzoate + 150 mg. /100 g. ascorbic acid.	
7.	Deaerated + 350 p.p.m. SO_2	(7) Overflow pasteurization	
8.	350 p.p.m. SO_2 +50 mg./100 g. ascorbic acid	(8) Deaerated + 350 p.p.m. SO_2	
9.	0·1 per cent sodium benzoate + 50 mg./100 g. ascorbic acid	(9) Deaerated + 350 p.p.m. SO_2 + 100 mg./100 g. ascorbic acid	
52° Brix squash in cans			
10.	Overflow pasteurization. Plain cans	(10) Deaerated & 350 p.p.m. SO_2 + 100 mg./100 g. ascorbic acid + nitrogen	
11.	Overflow pasteurization. Lacquared cans	(11) Deaerated + 350 p.p.m. SO_2 + nitrogen	
62° Brix squash in bottles			
12.	350 p.p.m. SO_2		
44° Brix squash in bottles			
13.	350 p.p.m. SO_2		

Refractometer solids, *p*H and tintometer colour readings were taken in all the treatments in three sets. Total titratable acidity, reducing sugars and total sugars were estimated in all the treatments under Set I and treatment Nos. 1 (350 p.p.m.

SO_2), 4 (0·1 per cent sodium benzoate), 7 (Overflow pasteurization) and 8 (deaerated + 350 p.p.m. SO_2) in Set II. Ascorbic acid was estimated in fortified lots. SO_2 was estimated in some cases only.

Samples in Set I were analysed after 9, 19, 30, 45 and 60 weeks of storage, while those in Sets II and III were analysed after 13, 29, 45 and 57 weeks.

Discussion

The analytical data are discussed under main heads in the following sections :

1. *Effect of method of preservation and temperature of storage on pH, acidity and refractometer solids*

*p*H (3·02), acidity (1·0 per cent as anhydrous citric acid) and refractometer solids remained practically unchanged under different methods of preservation as well as at different storage temperatures. The initial sugar concentration of the squash did not affect these values. In samples preserved with sodium benzoate, however, there was a slight increase of *p*H (0·05-0·10 units) in the case of addition of 0·1 per cent sodium benzoate and this remained constant during storage at differnt temperatures.

2. *Changes in reducing sugars, total sugars and degree of inversion during storage*

There was a gradual increase in reducing sugars, as well as degree of inversion during storage in all the methods of preservation, the increase being more in the case of the higher temperatures. The total sugars (expressed as invert sugar), however, remained unchanged at all storage temperatures.

The changes in reducing sugars, total sugars and degree of inversion were independent of the method of preservation and depended only on the time and temperature of storage. A few of the data are given in Table II.

It will be seen that the rate of increase of degree of inversion is greater where the initial value is lower. Although the initial values for the degree of inversion, of jack squash of 52° Brix in Sets I and II were 46·13 and 4·47 per cent respectively, both increased to 96·03 and 90·28 after a storage period of 19 and 13 weeks at room temperature. At 2-5°C also, the rise was quicker where the initial value was low. These data do not indicate any loss of sugars during storage as in the case of products like canned orange concentrate, etc. where slight decreases in sugars have been reported [Curl *et al.*, 1946; Hall 1927; Greer 1944].

3. *Changes in ascorbic acid during storage*

There is a continuous decrease with increase in the period of storage, in the ascorbic acid content of jack squash packed under various treatments, the rate of decrease being maximum at 37°C and minimum at 2-5°C. The percentage retention of ascorbic acid in squash fortified with 50 mg./100 g. of the vitamin packed under various treatments and stored at different temperatures are shown in Fig. I. The results in the case of other levels of fortification were similar. It will be seen that the temperature of storage is the most important factor determining the retention.

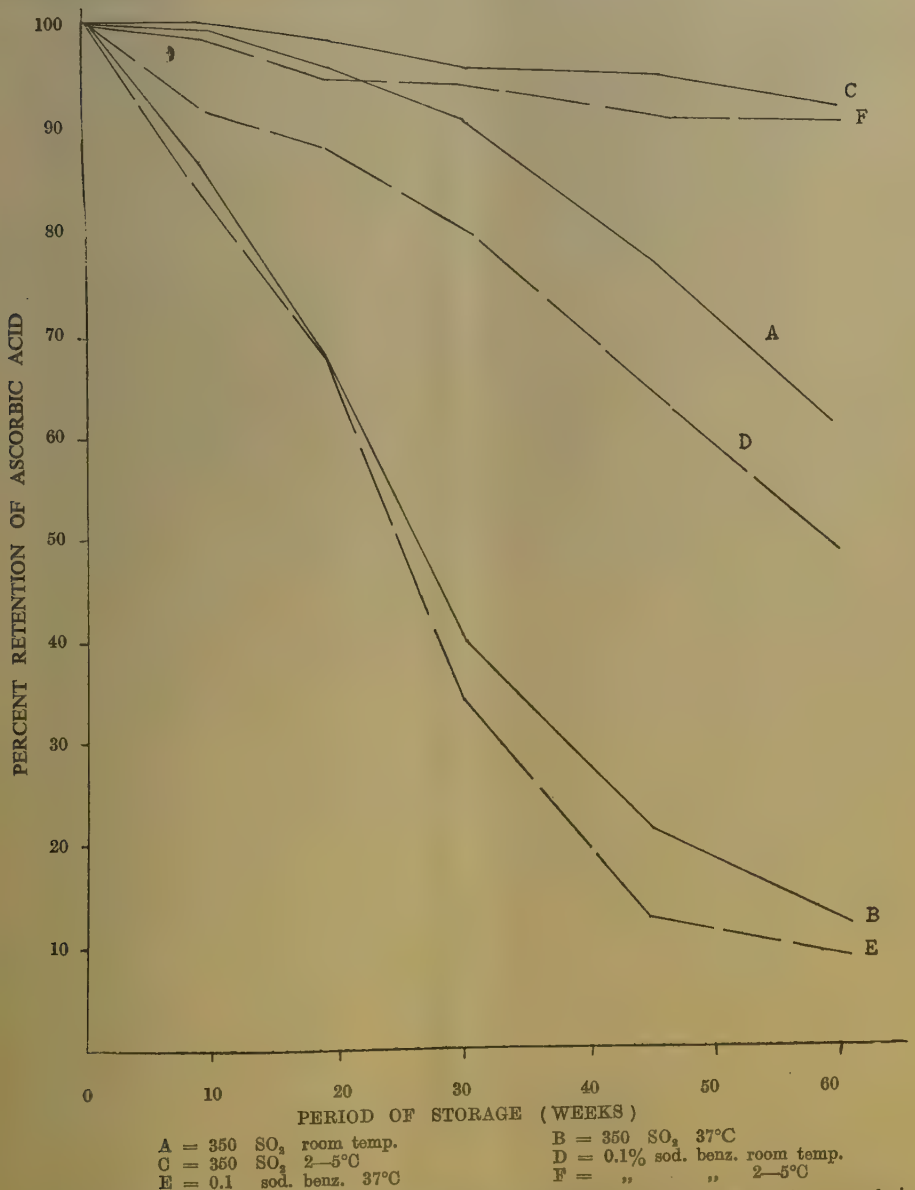

FIG. 1. Per cent retention of ascorbic acid in jack squash preserved with SO_2 and sodium benzoate during storage at different temperatures (squash fortified with 50 mg./100 g. asc. acid)

Table II

Changes in reducing sugars, total sugars and degree of inversion in squash of 44°, 52° and 62° Brix preserved with 350 p.p.m. SO_2 and stored at different temperatures over a storage period of 57-60 weeks

Period of storage (weeks)		Squash of 44° Brix, Set I			Squash of 52° Brix, Set I			Squash of 62° Brix, Set I			Squash of 52° Brix, Set II		
		Room temperature	37°C	2-5°C	Room temperature	37°C	2-5°C	Room temperature	37°C	2-5°C	Room temperature	37°C	2-5°C
Reducing sugars per cent (as invert sugar)	0	17·86	17·86	17·86	24·57	24·57	24·57	45·75	45·75	45·75	*2·28	2·28	2·28
	9	33·51	41·49	21·61	42·28	49·53	29·39	49·92	55·25	46·52	..	..	..
	13	..	..	..	..	..	..	..	..	..	44·92	51·68	15·17
	19	37·01	39·36	24·22	47·30	49·92	31·34	55·35	58·51	44·04	..	..	..
	30	44·22	42·54	24·80	50·91	51·68	34·15	55·95	57·93	46·16	49·83	50·30	23·92
	45	42·71	44·18	25·91	50·24	49·41	34·88	57·98	58·73	48·37	51·78	51·19	29·43
	57	..	..	..	..	..	..	..	..	..	..	..	30·69
	60	..	..	25·67	..	..	36·11	..	..	47·24	..	..	..

*Low initial reducing sugar values (2·28 per cent) in 52° Brix squash in Set II was obtained by taking care to add citric acid to the cold squash after mixing jack pulp and sugar syrup. In Set I, however, citric acid was added to the boiling syrup which resulted in a higher initial reducing sugar value.

TABLE II—(contd.)

Period of storage (weeks)		Squash of 44° Brix, Set I			Squash of 52° Brix, Set I			Squash of 62° Brix, Set I			Squash of 52° Brix, Set II		
		Room temperature	37°C	2-5°C	Room temperature	37°C	2-5°C	Room temperature	37°C	2-5°C	Room temperature	37°C	2-5°C
Total sugars per cent (as invert sugar)	0	43·13	43·13	43·13	53·28	53·28	53·28	61·55	61·55	61·55	51·10	51·10	51·10
	9	43·10	42·27	41·75	52·65	51·60	51·58	58·72	58·64	58·16	..	..	..
	13	..	..	..	..	..	..	..	..	..	49·75	51·68	50·42
	19	40·14	40·43	40·19	49·26	49·66	49·14	57·80	57·76	58·02	..	..	..
	30	42·03	41·95	42·41	52·60	51·40	52·02	56·30	57·55	57·82	51·22	51·13	51·69
	45	44·12	44·18	44·22	50·53	49·68	50·32	58·69	58·73	57·84	51·78	51·19	50·85
	57	..	..	..	..	..	..	..	..	..	..	..	50·51
	60	..	..	42·49	..	..	52·12	..	..	59·10	..	..	..
Degree of inversion per cent	0	41·41	41·41	41·41	46·13	46·13	46·13	74·32	74·32	74·32	4·47	4·47	4.47
	9	77·73	98·15	51·77	80·30	96·01	56·98	85·04	94·21	80·00	..	..	..
	13	..	..	..	..	..	..	..	..	..	90·28	100·00	30·69
	19	92·21	97·31	60·26	96·03	100·6	63·77	95·76	101·3	74·23	..	..	..
	30	100·5	101·2	58·22	96·79	100·6	65·64	99·38	100·7	79·84	97·27	98·37	46·28
	45	96·81	100·0	58·60	99·40	99·45	69·31	98·79	100·0	83·62	100·00	100·00	56·75
	57	..	..	..	..	..	..	..	..	..	..	..	60·77
	60	..	..	60·42	..	..	69·28	..	..	79·92	..	..	..

of ascorbic acid during storage. Irrespective of the level of fortification, the percentage retention during a storage period of 57-60 weeks under different treatments was 50-75 per cent at room temperature, 6-13 per cent at 37°C and 88-97 per cent at 2-5°C. Similar results were obtained by Lal [1943] in the case of citrus squashes. Further, there was a higher retention in samples preserved with SO_2 than in those preserved with sodium benzoate. Deaeration either alone, or combined with nitrogen packing, did not much influence the retention values, although it is commonly believed that oxygen is responsible to a great extent for the destruction of ascorbic acid in fruit products.

Changes in the apparent and true ascorbic acid content during storage of jack fruit squash. A few typical results of apparent and true ascorbic acid contents at the end of storage period, obtained in the case of squashes fortified at 50 mg./100 g. level are given in Table III. The results in the case of the other two levels of fortification were more or less similar. It was observed that at the end of a storage period of 57-60 weeks, apparent ascorbic acid under different treatments was formed to the extent of 5·5-12·2 per cent at room temperature, 40·1-100·0 per cent at 37°C and 3·6-11·9 per cent only at 2-5°C. Increase in storage temperature thus contributes towards the formation of apparent ascorbic acid. Deaeration, nitrogen packing and the nature of the preservative do not, however, appear to have any influence on the formation of apparent ascorbic acid.

TABLE III

True and apparent ascorbic acid in jack squash fortified with 50 mg./100 g. ascorbic acid and stored at different temperatures for 60 weeks after preservation with SO_2 or sodium benzoate

(*Values calculated as mg./100 g.*)

	Preserved with SO_2			Preserved with sodium benzoate		
	Room temperature	37°C	2-5°C	Room temperature	37°C	2-5°C
Total ascorbic acid	26·80	3·68	41·34	21·52	3·72	40·51
Apparent ascorbic acid	1·47	2·92	1·47	2·21	1·49	2·21
Per cent of apparent ascorbic acid in total ascorbic acid	5·49	79·36	3·56	10·27	40·05	5·46

There was no dehydroascorbic acid in the samples stored at 37°C showing thereby that the observed loss of ascorbic acid was a real one.

4. *Retention of sulphurdioxide during storage*

In Table IV are given the values of SO_2 in some of the sulphited samples analysed after a storage period of 32 weeks at room temperature and at 37°C.

TABLE IV

Retention of SO_2 in stored sulphited samples

Stored samples	SO_2 p.p.m.			Retention per cent	
	At start	After 32 weeks storage		Room temperature	37°C
		Room temperature	37°C		
52° Brix squash	350	112	64	32·0	18·3
	200	87	74	43·5	37·0
62° Brix squash	350	125	118	35·7	33·7
44° Brix squash	350	122	43	34·0	12·3

It will be seen that only about one-third of the original SO_2 content remains free at room temperature, while at 37°C the retention is considerably less.

5. *Colour changes during storage*

For obvious reasons of brevity the detailed tables have been omitted and only the important conclusions based on them are briefly discussed.

(i) *Effect of temperature of storage.* The temperature of storage is the most important factor determining the degree of colour development in the stored samples of the squash. After a storage period of 57-60 weeks all samples kept at 37°C turned orange to deep orange in colour while those at 2-5°C were still yellow. Samples preserved with benzoate or by pasteurization and stored at room temperature turned deep yellow to light orange, while those preserved with sulphur dioxide remained unaffected. At 37°C, the increase in yellow and red tintometer units started as early as 9-13 weeks of storage.

(ii) *Effect of different methods of preservation.* Of all the methods of preservation employed, preservation with sulphur dioxide showed the greatest protective action as regards colour retention. Samples preserved with sodium benzoate or by pasteurization (flash as well as over-flow pasteurization) showed a greater tendency towards darkening than those preserved with SO_2. There was no marked difference between preservation with 0·1 per cent and 0·05 per cent sodium benzoate and also 350 and 200 p.p.m. SO_2. The superior protective action of SO_2 may be due to its well-known antioxidant properties or bleaching action or its property of forming addition compounds with active carbonyl groups.

(iii) *Effect of deaeration and packing under nitrogen gas.* Removal of air or packing under nitrogen gas did not show any advantage over the controls as regards checking deterioration in colour during storage. Similar observations have been reported by Pederson *et al.* [1941] in the case of strawberry and currant juices.

(iv) *Effect of different sugar concentrations.* Up to a storage period of 30 weeks at 37°C there was not much difference in the intensity of colour formed in squashes of 44°, 52° and 62° Brix. On prolonged storage for 60 weeks, however, there was comparatively greater darkening in squashes of 62° and 52° Brix as compared with squash of 44° Brix. This is in confirmation of common observation of many workers that sweetening of citrus juices tends to increase the rate of browning.

(v) *Effect of fortification with ascorbic acid.* Tintometer readings of samples stored at 37°C in Set II showed that the addition of ascorbic acid, especially higher quantities (100 and 150 mg./100 g.), influenced the rate of browning to a considerable degree. After 57 weeks of storage at 37°C, the red tintometer units in samples preserved with SO_2 and sodium benzoate were 4·8 and 5·5 respectively. On the other hand, similar figures for samples fortified with 150 mg./100 g. ascorbic acid were 9·0 and 9·8. One possible explanation for this is that ascorbic acid is directly involved in colour development. There are, however, several conflicting views in this aspect. According to Hamburger and Joslyn [1941], ascorbic acid acts as an antioxidant and checks the development of colour. On the other hand, Loeffler [1941], Moore *et al.*, [1942], Chaves [1945] and Curl *et al.*, [1946] have pointed out that browning is always associated with the destruction of ascorbic acid. Moore *et al.*, [1942] and Beattie *et al.*, [1943] have confirmed this in the case of orange and strawberry juices by showing that addition of ascorbic acid led to a marked increase in the browning. The present results in the case of jack squash are of special importance because in this case, the squash as such, is almost completely devoid of natural ascorbic acid. The absence of any dehydroascorbic acid in squash stored at 37°C for long periods shows that any dehydroascorbic acid formed at the early stages might have been destroyed completely during the subsequent reactions leading to colour changes in the squash.

(vi) *Effect of type of container.* At the end of storage for 60 weeks at room temperature, darkening was slightly more in pasteurized samples packed in bottles than in those packed in plain or lacquered cans. This is due to the well-known protective action of tinplate as well as elimination of light in the canned product. There was, however, no difference between the samples packed in plain or lacquered cans.

6. *Organoleptic evaluation*

All samples stored at room temperature and in the refrigerator retained their characteristic jack fruit taste and aroma throughout the period of storage. The flavour was slightly milder in samples stored at 37°C. The change was not prominent because of the original strong flavour of the squash at the time of packing. After a storage period of one year, the samples stored at 37°C developed a kind of caramelised off taste which was more pronounced in samples preserved with sodium benzoate than in others. Samples containing added ascorbic acid and preserved

with SO_2 retained the full flavour. The presence of SO_2 in sulphited samples was not noticeable. There was no perceptible difference of quality among squashes of 44°, 52° and 62° Brix or those deaerated or packed in nitrogen or air.

Summary

1. A detailed study has been made of the changes in some physical and chemical characteristics of jack fruit squash during a storage period of about 60 weeks at room temperature (24-30°C), 37°C, and 2-5°C.

2. Refractometer solids, *p*H and total titratable acidity remained unchanged throughout the storage period at all the temperatures.

3. Reducing sugars and the degree of inversion increased during storage at all temperatures, the rate of increase being higher at 37°C than at room temperature or at 2-5°C. The total sugars, however, remained unchanged.

4. Temperature of storage is the most important single factor that influenced the retention of ascorbic acid in the squash. Irrespective of the level of fortification, the percentage retention during a storage period of about 60 weeks was 50-75 per cent at room temperature, 6-13 per cent at 37°C and 88-97 per cent at 2-5°C. The retention was more in samples preserved with SO_2 than in those preserved with sodium benzoate. Deaeration, alone or combined with nitrogen packing, did not much influence the retention values. There was no dehydroascorbic acid in the preserved squash.

5. At room temperature, only about one-third of the original added SO_2 (200 or 350 p.p.m.) remained in free form after 32 weeks of storage. At 37°C, the free SO_2 content was still less.

6. Samples stored at room temperature and 2-5°C retained their original colour during a storage period of about 60 weeks. At 37°C, however, considerable darkening of colour was noticed. Preservation with SO_2 affords the maximum protective action as regards colour change. Removal of air or packing under nitrogen gas did not show any advantage over the controls in checking deterioration in colour. There was comparatively greater darkening in squashes, of higher Brix (52-62°) than in squash of lower Brix (44°). Addition of ascorbic acid increased the darkening of colour.

7. The squash retained its normal colour, characteristic fruit taste and aroma during the entire storage period of about 60 weeks at room temperature of 24-30°C and at 2-5°C. At 37°C, however, there was considerable deterioration in its quality.

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NUTRITIVE VALUE OF GRASSES OF JAMMU AND KASHMIR

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INDIA is one of the largest livestock rearing countries of the world having 136 million cattle and 40 million buffaloes which together constitute about a quarter of the world's total bovine population. In addition, India has 37·7 million sheep, 46·5 million goats, and 3·2 million other animals comprising horses, mules, donkeys, and camels, all playing a vital part in the agricultural economy of the country. In spite of the fact that India possesses such a large number of domestic animals, it has been found that they are mostly undernourished. The quality of the livestock is, therefore, generally very poor and the *per capita* production of milk from them is perhaps the lowest in the world [Datar Singh, 1950].

The usual sources of cattle feed in India are fodder crops, by-products of cereals and natural grazing grass in hills, plains, and forest areas. At present the cattle largely depend upon the by-products of food crops supplemented by whatever green roughage they can pick up in the grazing lands which are generally poorly stocked. In an agricultural country like India, where about 70 per cent of the population is directly engaged in agricultural pursuits, the maintenance of cattle for the cultivation of land, milk supply, and certain other purposes is a matter of utmost importance. For healthy growth of animals it is essential that they are given adequate feeds containing proper amounts of all the food constituents in order to ensure a steady development [Datar Singh, 1950].

There are enormous potentialities in the country for increasing the production of fodder materials and very useful work has been done by Sen [1938] on the nutritive value of Indian cattle foods and the feeding of animals.

Livestock improvement requires simultaneous attention to a number of factors, viz. breeding of quality animals, provision of good nourishing food, disease control and management. Feeding the animals adequate quantities of fodders is one of the vital problems facing India particularly the State of Jammu and Kashmir. This State with nearly three million cattle population is one of the largest livestock rearing States in India. According to the last census report it has 1·3 million cattle and buffaloes which are mostly employed for agricultural purposes and for the production of milk. There are about 90,000 horses, donkeys, camels, mules, and yaks which are employed for the transport of goods in hill tracts. Donkeys and camels are mostly used in the *Kandi* (dry hills) areas of Jammu province and yaks for carrying

supplies to trans-Himalayan regions in Ladakh. The State has about 1·5 million goats and sheep which are mainly reared for the production of wool which is supplied to the cottage industry in the State as well as for export purposes.

In order to assess the easily available nutritious grazing material for feeding the livestock in the State and as a first step towards the improvement of feeds of animals, a careful survey of the grazing areas and collection of samples especially of grasses for study of their nutritive value was undertaken. Considerable areas in Jammu and Kashmir form the pasture lands and forest blocks. The occupation of the rural population in this area is the rearing of livestock. In search of good pastures and grasslands, the cattle migrate seasonally from one place to another, to plains and hills and in the forest blocks. The standard of the livestock in the State like other parts of India is poor and the animals are mostly undernourished due to underfeeding. The important pre-requisite to improve the livestock is to find good nourishing fodder materials in these pastures. If the nutritive value of the various grasses and other fodders on which animals subsist is known, livestock can be improved by feeding them nutritive grasses exclusively.

In the course of this study, vast areas at altitudes varying from 800 ft. to 14,000 ft. above sea level were surveyed. About 300 representative samples of grasses and sedges were collected and their nutritive values determined by analysis. The samples were collected mostly at the flowering stage and dried. The identification of the grasses and sedges was confirmed by the Superintendent of Botanical Garden, Calcutta. The vernacular names of the grasses have been given where it has been possible to find them. It is curious to note that the majority of the local inhabitants did not have any specific vernacular name for a particular grass but simply called '*gaha*' or '*ghas*'.

Normal constituents of foodstuffs

The important constituents of foodstuffs normally are proteins, fats, carbohydrates, mineral matter, and vitamins.

Proteins play a double role in the nourishment of animals and must necessarily be provided in adequate quantity. They are essential for growth, for repairing wear and tear of the tissues, and for production of milk along with fats and carbohydrates. On Oxidation in the animal body, the carbohydrates are responsible for giving energy for work, keeping the animals warm ; when the animals are fed in excess of the requirement they become very fat. Mineral matter is chiefly responsible for building up the skeleton and is essential for metabolism. Vitamins, though required only in small quantities, are absolutely essential and play a unique role in regulating the life processes. In their absence, animals, in spite of getting other nutrients in adequate quantities, suffer from deficiency diseases such as poor growth, rickets, deformed bones and teeth, etc. That is why green fodder, in which there is abundance of vitamins is recommended to form at least half the quantity of the total daily food of each animal.

Method of analysis

The analysis of grasses consists in determination of moisture, proteins, ether extractives, mineral matter, crude fibre, carbohydrates, calcium oxide, phosphorous pentoxide, calorific value, detection of poisonous constituents such as hydrocyanic acid, etc. The methods employed were mostly standard ones [Knowles and Walkins, 1947]. The analytical results of the various samples of grasses collected during the survey from different places is given in Appendix I.

In this preliminary survey about 124 species of fodder plants growing wild throughout the State have been recorded. Out of these, 114 belong to the family *gramineae* and 10 to the family *Cyperaceae*. It has been observed that some of these are found as 'escapes' (growing haphazardly) while some of them are just in small patches which cannot be considered as fodders. It is interesting to observe that about 22 plants found either in Jammu or in Kashmir provinces are growing in abundance and provide vegetative herbage for the livestock. These are recorded below.

1. *Agrostis alba* Linn. 2. *Alopecurus geniculatus* Linn. 3. *Apluda mutica* Linn. 4. *Arthraxon lanceolatus* Hochst. 5. *Andropogon aucheri* Boiss. 6. *Cymbopogon jwarancusa* Jones. 7. *Dactylis glomerata* Linn. 8. *Erianthus fulvus* Nees. 9. *Ischaemum angustifolia* Hack C. E. Hubbarad. 10. *Festuca rubra* Linn. 11. *Hetropogon contortus* Beauv. ex.R. S. 12. *Lolium temulentum* Linn. 13. *Panicum antidotale* Retz. 14. *pennisetum flaccidum* Greseb. 15. *P. orientale* Rich. 16. *Poa augustifolia* Linn. 17. *P. annua* Linn. 18. *P. sterilis* Bieb. 19. *Polypogon littoralis* Sm. 20. *P. monspeliensis* (L) Desf. 21. *Sorghum halepense* Pers. 22. *Eriophorum comosum* Wall.

The grasses number 1, 2, 3, 5, 10, 11, 12, 13, 15, 16, 17, 18, 19, 21, and 22 have been discussed in detail in the text, data regarding the distribution and calorific value of the remaining are given in Table I.

Table I

Analytical results of various grasses

Name	Calorific value	Distribution in the State
1. *Apluda mutica*	199-244	Jammu, Poonch, Mendhar, Rajouri, Batote, Ramban, Uri
2. *Andropogon aucheri*	180-231	Ramnagar, Kathua, Akhnoor
3. *Dactylis glomeratea*	217-243	Verinag, Bhadarwah, Kishtwar, Yarikha
4. *Erianthus fulvus*	191-243	Jammu, Akhnoor, Kishtwar, Kathua
5. *Ischaemum angustifolia*	205-238	Ramnagar, Jammu, Reasi, Mendhar, Sunderbani, Bhadrawah, Doda
6. *Pennisetum flaccidum*	209-248	Srinagar, Poonch, Dachigaum, Ramban Uri
7. *Polypogon mospeliensis*	210-243	Jammu, Poonch, Rajouri

A study of Appendix I reveals that there are about 28 grasses which possess good nutritive value, i.e. having calorific value of 250 or above. The list of such plants together with their distribution and calorific values is recorded in Table II.

TABLE II

Grasses and their calorific values

Name	Calorific value per 100g.	Distribution
1. *Agrostis alba* Linn.	250·6	Ramban (200 ft.)
2. *Alopecurus geniculatus* Linn.	271·0	Yarikah (7000 ft.)
3. *Arthraxon lanceolatus* Hotchst	262·2	Batote (550 ft.)
4. *Bromus japanicus* Thunb	280·5	Batote (5500 ft.)
5. *B. oxyodon* Schrenk	251·0	Bhadarwah (5000 ft.)
6. *Cymbopogon jwarancusa* Jones	257·6	Ramnagar (2500 ft.)
7. *Cynodon daciylon* Pers	283·6	Jammu (1200 ft.)
8. *Echinochloa crusgalli* Beauv	250·5	Yarikah (7000 ft.)
9. *Eragrostis viscosa* Trin	253·6	Kathua (900 ft.)
10. *Erianthus ravennae* Beauv	253·9	Kathua (900 ft.)
11. *Festuca rubra* Linn	289·4	Tangmarg (7000 ft.)
12. *Hemarthria compressa* Kunth	255·9	Yarikah (7000 ft.)
13. *Lolium temulentum* Linn	267·7	Yarikah (7000 ft.)
14. *Panicum antidotale* Retz	255·2	Ramnagar (2500 ft.)
15. *Pennisetum orientale* Rich	278·1	Kathua (900 ft.)
16. *Poa angustifolia* Linn	257·4	Yarikah (7000 ft.)
17. *Poa annua* Linn	268·9	Kishtwar (5300 ft.)
18. *Poa sterilis* Bieb	251·6	Ramban (2000 ft.)
	267·4	Yusmaidan (9000 ft.)
19. *Polypogon littoralis*	264·1	Kishtwar (5300 ft.)
20. *Setaria viridis* Beauv	253·3	Yarikah (7000 ft.)
21. *Sporobolus diander* Beauv	257·6	Akhnoor (1000 ft.)
22. *Stipa orientalis* Trim	290·0	Srinagar (5000 ft.)
23. *Themeda anathera* Hack	262·4	Poonch (3500 ft.)
24. *Carex notha* Kunth	255·8	Yarikah (7000 ft.)
25. *C. nubigena* D. Don	267·7	Yarikah (7000 ft.)
26. *C. setigera* D. Don	253·0	Batote (5500 ft.)
27. *C. vulgaris* Fries	253·7	Gulmarg (9000 ft.)
28. *Eriophorum comosum* Wall	268·4	Akhnoor (1000 ft.) Banihal Pass (9000 ft.)

A short descriptive account of these grasses and sedges is given below which may be helpful to the workers engaged in the improvement of pastures and grasslands.

1. *Agrostis alba* Linn.

This grass is found in the western Himalayas from Kashmir to Kumaon. It is reported to have been introduced in Sikkim and Nilgiris. The stems are erect, slender, stoutly ascending from a tufted base. The leaves are rather short and flat. The panicle is about six inches long, pyramidal and the spikelets are green or purplish. It grows in Gulmarg, Khilenmarg, and Kosarang in the Kashmir valley and in Ramban area in the Chenab valley. It is a perennial grass and regenerates profusely. It is quite a good fodder.

Alopecurus geniculatus Linn.

This grass is reported to be growing in temperate and sub-tropical Himalayas at altitudes of 3,000 to 7,000 ft. from Kashmir to Bhutan.

The grass has slender and geniculate stem with greenish-yellow panicles. This is an annual grass growing quite commonly at low and high altitudes in the State. It is particularly common in Kathua and Yarikah and is used as fodder by inhabitants of these areas.

Arthraxon lanceolatus Hochst.

This is a tall, much-branched grass with rigid stem. The leaves are 2-3 inches long, lanceolate and with few spikes. The plant is reported to be growing in the western Himalayas from Kashmir to Nepal as also in the plains of the Punjab. In the State it grows in Dachigaum, Batote, Rajouri and Reasi. The grass is found commonly in these places and is used both as fodder and hay in these areas.

Bromus oxyodon Schr.

This is an annual grass with tall ascending erect stems. The leaves are linear and hairy. The panicles are stiff; spikelets are linear and oblong. The plant is reported to be growing in the inner dry Himalayas, i.e. Dras, Baltistan, Zanskar at altitudes of 9,000 to 12,000 ft. and in Bhadrawah, Mendhar and round about Srinagar at lower elevations. Another species of the same genus, i.e. *B. patulus* Mert & Koch Sv is found growing in the Western Himalayas and has been collected from Batote at an altitude of 5,000 ft. and at Jammu (900 ft. above sea level). Both these species are found in abundance in the State and can serve as good fodder.

Carex nubigena D. Dn.

The plant has a short perennial rhizome and bears long slender stems with long (lower) leaves; inflorescence is dense but interrupted. The spikes are small but dense.

The plant grows in the Himalayas at altitudes of 5,000 to 13,000 ft. It grows in the State in Yarikah where it is common but is not much used as fodder.

Carex vulgaris Fries.

This herb is found commonly in the inner dry Himalayas at altitudes of 10,000 to 13,000 ft. The stems of the plant are often 10 to 20 inches high with conduplicate leaves. The spikes are less close and longer. The urticle is slenderly curved. It is distributed throughout the cooler parts of the world. Its collection was made from Gulmarg area where it is also not much common. Its use as fodder is also not much reported.

Cymbopogon jwarancusa (Jones Schult.)

Syn. Andropogon Jwarancusa Jones

(Vern. Khus, Jara, Khavi)

It is a perennial aromatic grass with a stout rhizomatous root-stock. The culms are 60 cm. tall with short internodes at the base and many overlapping sheaths. The leaf blades are flat. The inflorescence is panicle or more or less racemosely arranged in pairs.

This species is very widespread. It grows over the whole of Northern India from Assam to Baluchistan and is particularly common in areas of low rainfall and high temperature. The plant has aromatic odour but the roots contain more percentage of oil than the rest of the plant.

Apart from being an essential oil bearing grass the plant is nutritious from fodder point of view.

In the State this grass is common in Ramnagar and Reasi but is not much used as fodder.

Cynondon dactylon Pers.

(Vern. Bhub)

This is a perennial grass with prostrate and creeping culms. It generally roots at the nodes and often forms a wide mat on the surface of the soil. Leaves are short and deep green in colour. The inflorescene is a whorl of two to six spikes radiating from the top of slender peduncle. Spikes are one to two inches long, covered with unilateral rows.

This grass readily takes possession of abandoned cultivation, paths and depressions where water collects. It survives well on moderately grazed ground as it stands moderate trampling and the prostrate stems ensure its survival.

It is considered to be one of the best fodder grasses perhaps the best for horses. It is often used in India as a diuretic and sedative in cystitis and other diseases. It is a good sand binder and excels carpet grass for making lawns. Its propagation is easy by divided runners or by seed or by sections of turf. It is found distributed in various localities all over Jammu and Kashmir State and in India.

Echinochloa crusgalli Beauv.

Vern. Sarvank, Hama

This is an annual grass with erect and simple stems up to three feet in length and linear and flat leaves. The receme is usually inclined and the spikes are sessile.

It is found throughout India especially in wet places and rich soils. In the State it grows in Kukarnag (550 ft.), Toshaidan (9.000 ft.), and Yarikah (7.000 ft.). It is a fairly common grass and is found all over the valley. The grass when young is relished by cattle while its grains are used as food by poor people.

Eragrostis viscosa Trin.

(*E. Tenella* Roem & Seh).

Vern. Bhurbur

This grass is found in the plains and lower hills throughout India. It is a sub-gregarious species which is common in damp places and is distributed throughout the southern Gangetic plains. In the State it is fairly common in Kathua and the neighbouring areas. It is eaten by cattle both in the fresh and dry state.

Erianthus ravennae Beauv.

(Vern Dolsar, Dolu)

This is a tall grass 6-10 ft. long with 2-3 ft. long linear leaves. The panicle is 1 ft. long, erect and greyish, white with silky villous hairs. It is found on sandy and clayey loam soil and requires liberal supply of available moisture. The plant is found in Western Himalayas from Kashmir to Kumaon, the Punjab, and Uttar Pradesh. In the State it grows in Kathua, Poonch, and Udhampur in Jammu Province and is quite common in these localities. Its clums are used for making screens, etc. The leaves quickly decay and, therefore, are useless for thatching. The leaves especially when young are eaten to some extent by buffaloes.

Eriophorum comosum Wall.

The herb has robust stems and compared umbel. The spikelets are many. It is a very common plant found in the plains and in the Himalayas up to an altitude of 10,000 ft. It is distributed all over the State and is common in Akhnoor, Jammu, Rajouri, and Reasi and Banihal Pass and is used as fodder in all these places.

Festuca rubra Linn.

The grass has erect and geniculate stems with caulin and linear leaves. The panicle is narrow and nodding. The spikelets are green and glabrous.

The plant is found in temperate and subalpine Himalayas at 6,000 to 13,000 ft. above the sea level. It grows in the State in Gulmarg, Tangmarg, Yarikah at altitudes of over 7,000 ft. and is in quite abundance there. It is used as cattle fodder.

Hemarthria compressa R. Br.

Syn. *Rottboellia compressa* linn.

(Vern. Baika)

This grass is found throughout the hotter parts of India generally in wet places. It is an erect, branching, and leafy grass and the leaves are linear and the mouth of the sheath is hairy. The spikes are solitary, long, and slender.

It is very common in Jammu and cattle relish this grass very much.

Lolium temulentum Linn.

This is an annual grass and has an erect stem with smooth sheathed leaves. The spike is 8-10 inches with stout rachis and spikelets variable in size.

The plant is found in the plains and also in the Western Himalayas from 4,000 to 6,000 ft. above the sea level. It was collected from Yarikah, Rajouri, Kathua, and Kishtwar and is met with in abundance in these places.

Panicum antidotale Retz.

(Vern. Ghamor, Gharram)

This is a perennial tall grass with stout creeping rootstock. The leaves are linear, flat with round base. The panicles are large, effuse or contracted and branches are slender. Spikelets are glabrous.

The plant is reported to be growing in the Punjab and Upper Gangetic plains. This grass grows in Akhnoor, Jammu, Nowshehra and Ramnagar in Jammu Province and is quite common at these places. Reports as to the value of this grass as fodder are conflicting. It was reported by Duthie that its real fodder value commences at those periods when the better class of grasses fail. It is said to be eaten when young as afterwards it acquires a saltish and bitter taste. It is reported to have medicinal value in throat affections, for fumigating wounds and as an antidote for hydrophobia.

Pennisetum orientale Rich.

(Vern. Birnalsia)

This is a perennial grass ascending from a densely tufted and stout creeping rootstock. The leaves are long, narrowly linear, and hairy. The rachis of spike is hairy, and spikelets in small pedicle.

The plant is found in the Western Himalayas from Kashmir to Kumaon and also in the Punjab, Sind, etc. In the State it has been found growing in Kathua, Rajouri, Reasi, and Thratay in Jammu Province but is not much used as fodder in these places.

Poa angustifolia Linn.

Syn. Poa pratensis Linn

This is tall stout and stoloniferous grass. The leaves are very narrow and setaceous, crowded at the base of the stem. The panicle is about four inches long with green and pedicelled spikelets. The plant is found in the Western Himalayas from Kashmir to Kumaon.

It grows in Srinagar, Gulmarg, Yarikah, and Tangmarg places which are all above 5,000 ft.

Poa annua Linn.

This is an annual stoloniferous grass with stem shortly creeping and slender. The stems are geniculate and slightly compressed. The leaves are small and linear. The panicle is rigid and solitary and spreading. The spikelets are pedicelled and green in colour.

This grass occurs in temperate and subalpine Himalayas. It grows in Batote, Doda, Kishtwar, Srinagar, and Dachgam. It is found abundantly in these places and is used as fodder both in the green and dry state by the local inhabitants.

P. attenuata Trin

Syn. *P. Sterilis* M. Bieb.

The grass has erect and tufted stems with one or two leaves above. The leaves are linear. The sheaths are white and scarious. The panicle is contracted and densely flowered. It is reported to grow in alpine Himalayas at altitudes of 13,000 to 17,000 ft. In the State it grows in Gulmarg, Dharamsala, Kishtwar, Ramban, Yarikah, and Toshmaidan but it finds use as fodder to a very limited extent.

Polypogon littoralis Sm.

This is a perennial grass with lobed panicles. The stems are slender with geniculate base. The leaves are green with ligule.

The plant is mostly found in temperate Himalayas at altitudes of 4,000 to 10,000 ft. from Kashmir to Bhutan. It grows in Bhadrawah, Doda, Jammu, Kishtwar, Sanderbani, and Srinagar and is commonly grazed by the cattle.

Sporobolus diander Beauv.

(Vern. Chirya-ka-dana)

This is a slender grass with stem about 1-2 ft. high and leaves densely tufted. The panicle is borne on a slender rachis. The spikelets are sessible. It is a spordiac species and likes moist pasture ground. The grass is found throughout India. It is found growing in Akhnoor area in the State. It is a favourite fodder grass for cattle and horses. It has been found only in one situation in the State and is not much used as fodder. It is a very nutritious grass and its propagation in Akhnoor area and other places will be advantageous.

Stipa orientalis Trin.

The stems of the grass form a dense hard tuft and are clothed below with shinning sheaths. The panicle is narrow and elongated. The leaves are filiform and the tops are long and capillary. It is reported to be growing in Western Tibet at altitudes of 10,000 to 15,000 ft.

The sample of the grass was collected from Srinagar where it most probably is an 'escape' grass.

Carex notha Kunth.

This plant belongs to the family *Cyperaceae* and is grazed with relish. The plant bears 3 to 1 spikes on slender peduncles. The clums are green.

The herb grows in Western Himalayas from 5,000 to 11,000 ft. above sea level. It grows in abundance in Yarikah and Batote in the State and is much used as fodder for cattle and horses.

A perusal of the above statement on grasses also shows that out of the large number of samples of grasses tested in the fresh condition for the presence of hydrocyanic acid, there were seven which showed presence of it. It has been observed that these grasses in the green condition produce deleterious effect and some times death in the livestock when animals feed on these. This effect is considerably reduced in the dry condition and so are sometimes used in hay form. These grasses and sedges are :

1. *Bambusa arundinacea*
2. *Carex brunnea*
3. *Pennisetum lanatum*
4. *Saccharum spontaneum*
5. *Sorghum halpense*
6. *Stipa siberica*
7. *Themede anathera* Hack.

Some of these plants are well represented throughout India particularly in Uttar Pradesh, Madhya Pradesh, Delhi, the Punjab, etc.

Bambusa arundinacea Willd.

(Vern. Kalak Mundi, Bansa)

This plant is commonly found wild and cultivated throughout the plains and low hills of India. It is cultivated only in the lower Himalayas and in the valleys of the Ganges and the Indus rivers. The plant assumes a length up to 40 ft. and diameter up to 6-7 inches. The stem sheath has felted hairs and the leaves are linear, and long up to 8 inches. The plant flowers gregariously and in small clumps. The young shoots of the plant were found to contain hydrocyanic acid. Poisonous cases, though not fatal, have been reported in cattle grazing young shoots of this plant.

Carex brunnea. Thunb.

This plant belongs to the family *Cyperaceae.* It is a grass-like herb found in the North-Western Himalayas at altitudes of 4,500 to 6,000 ft. It has also been reported in Manipur, Assam, the Nilgiris, etc. The plant was collected from Batote (5,000 ft.). It is quite common but there is no record of its fatal effects through hydrocyanic acid which was found only in traces in the fresh grass.

It grows commonly in Kathua and Basohli areas and its young leaves when taken by the cattle have been reported to cause poisoning.

Pennisetum lanatum Flotz.

This plant grows wild in the Western Himalayas from Kashmir to Garhwal and Western Tibet.

This is a perennial grass with stout rootstock and with stems 1 to 3 ft. high. The leaves are 6-18 inches long with hairy villous. The spikes have pale green colour, and the spikelets are solitary in the involucles.

The plant is not common and was found near the Dachigam Rakh in Kashmir Province and near Ramban in Jammu.

The samples of the grass collected from both the places showed the presence of traces of Hydrocyanic acid in the fresh condition. The nutritive value is about 272. It is likely that in the dry stage the acid may get removed and the grass may prove useful as hay.

It is reported to have toxic effects but no mortality of cattle has been reported when grazed on this grass.

Saccharum spontaneum Liumm.

(Vern. Kans, Khus)

The plant grows in Jammu Province in the districts of Kathua, Reasi and Jammu. It occurs in Mussouri, Dehradun, Saharanpur, Ranikhet, Ramnagar, Behraich, Kanpur and Kheri in Uttar Pradesh.

It is a very variable perennial grass with its culms reaching a height upto 20 ft. which is solid above and fistular below and covered with a glabrous bloom when young. The leaves are erect, up to 5 ft. in length and very narrow ; sheaths are longer than internodes, often with reddish or purplish blotches, glabrous or with scattered hairs. The inflorescense is a silvery panicle appearing at the end of rains. If the spikelets are examined with a hand lens, the lower glumes are found to be brown at the base and colourless at the top.

The plant is commonly found on the river banks in damp depressions and in swamps which dry up in the cold weather where it is decidedly gregarious. In spite of these common habitats this grass is xerophilous and is found colonising newly thrown up sand banks. It is most accommodating and is at home on loose as well as badly aerated soils and in dry and moist situations. The plant flowers at the end of rains. This grass develops a dense mass of roots in the upper 8 in. of the soil and can best be eradicated by tractor cultivation.

S. spontaneum is one of the best grasses for thatching. According to Bor it is a favourite buffalo fodder, especially the hygrophilois form with broad leaves, common near streams. It is found in the moistest portion of lands adjoining the rivers where it affords most valuable pasturage for buffaloes.

Sorghum halpense Pers.

(Vern. Baru)

It is also a very important grass which is distributed throughout Tehrigarhwal, Mussouri, Haldwani, Saharanpur, Kanpur, etc. in Uttar Pradesh. The plant is locally found in Kathua, Udhampur, Reasi and Jammu districts. It is a perennial grass with erect, tall, smooth, glabrous and polished culms. The leaves are up to 2 ft. in length, linear, lanceolate, smooth and glabrous. The inflorence is a panicle up to 18 inches in length and pyramidal in shape.

It is a gregarious grass and is found common in cultivated and uncultivated soil, also in hedges and along the banks of water courses. It appears to thrive best on the well drained soils.

According to Bor this grass is believed to be a good fodder and the grain can be used as food in times of scarcity. For hay it is suitable if cut when not more than 3 ft. high while it makes excellent silage.

Chopra and Badhwar instance *Sorghum halpenses* and *S. vulgare* as two grasses which have caused serious outbreaks of poisoning among livestock when wilted or stunted through drought conditions. *S. halpense* is said to be responsible for serious losses in North-Western Frontier Province (Pakistan). The poisonous element seems to be hydrocyanic acid which is said to grow less with age but does not disappear entirely. The plants if well dried are not dangerous.

Owners of horses, cattle and other stock should avoid the grass after the period of drought and if grass is cut and carried from the field to the stable it should be examined for young plants of the species before being fed to the animals.

Stipa siberica Lamk.

This grass grows profusely in Jammu and Kashmir forests at altitudes of 5,000 to 9,000 ft. It is found in the Western temperate Himalayas from Kashmir to Kunawar and also in Afghanistan and Siberia to Korea.

The grass is 2 to 3 ft. tall with 1 to 2 ft. long flat leaves. The panicle is 6-12 inches with elongate and very narrow and erect branches. It is a perennial and hardy species and at certain places in Kashmir this forms the major undergrowth cover of the pine forests. The qualitative tests done with fresh grass showed the presence of hydrocyanic acid in it. The horses, ponies and mules exhibit fatal effects when grazed on this grass especially when green. The local people do not allow their livestock to graze on this grass. Cases of poisoning have been reported during military operations in Kashmir when some mules of Defence forces grazed on this grass. The inhabitants also use this grass to fumigate bad sores and wounds.

The mede anathera Hack.

(Vern. Ghatira)

It is found in Gonda and Dehra Dun in Uttar Pradesh. In Jammu and Kashmir the plant is found in Banihal, Bandipur, Poonch, Ramban, Udhampur, etc. It is a perennial, tufted and gregarious grass with culms upto 4 ft. height. The leaves are very narrow and the panicle elongate. This grass is usually found between 6,000 to 8,000 ft. and its appearance in the plains is accidental. This is a grass of sheltered shady slopes and is often the only undergrowth in the *Chir* forests in the Kulu valley. It flowers at the end of rains. The samples of grass growing has been found to possess calorific value above 250 but hydrocyanic acid has been detected in the green stage. It is likely that when the plant matures and is used as hay, this acid may not be there. The local people have reported poisoning cases in cattle when fed with fresh grass.

Conclusion

From a perusal of the data given in this paper it will be seen that in Jammu and Kashmir about 30 different grasses and sedges are reported to grow which on analysis have been shown to be important from the point of view of animal nutrition. There are also grasses which when grazed upon by animals produce undesirable toxic effect. Of the nutrient grasses not more than 20 have been found to grow abundantly in some part of the State or other. These are the grasses whose propagation should be encouraged.

The eradication of poisonous grassesis important and should receive attention. Although no proper statistics are available these grasses undoubtedly must be causing considerable loss to the livestock as can be conjectured from statistics available in other countries. So far neither a comprehensive survey of poisonous grasses nor of other fodders has been carried out in India with a view to investigating their poisonous properties.

In order to improve the quality of grasslands it is necessary that there should be controlled grazing so that proper time is available for regeneration. The peasantry should be educated with regard to the identification of good nourishing grasses which should be developed and poisonous grasses which might grow in their neighbourhood should be eradicated. This should not be difficult as the common poisonous grasses are fairly well known to the people in the neighbouring areas in which they grow. Ordinarily cattle avoid the poisonous grasses instinctively but during winter when there is deficiency of good fodder, by force of necessity they resort to eating them to make up the roughage required.

The places where good nourishing grasses grow should be protected and should be open only to grazing by rotation. The protection thus afforded will help in the preservation and propagation and in this way both quality and quantity will improve. The nutritive species of grasses may preferably be introduced in such areas where vast tracts are covered with grasses which are not of good quality. The fodder

supply can also be improved by the introduction of exotic species of good nourishing grasses and clovers in the available area where their natural growth can be encouraged till they are well established. It was observed that grasses such as *Agrostis alba, Andropogon, Eragrostis viscosa, Erianthus ravennae, Panicum antidotale, Pennisetum orientale, Poa sterilis, Sporobolus diander, Themeda anthera* and *Eriophorum comosum* grow commonly in various regions of Jammu Province. Their calorific value per 100 gm. is indicative of their good nourishing qualities. If these grasses are introduced and propagated scientifically and systematically in adjoining grazing areas wherefrom they have been reported, it will be helpful in improving the quality of the cattle in these areas.

In Kashmir province the following grasses with good nutritive values have been found growing in various localities such as Tangmarg and grazing areas in the valley of Yashmaidan at altitudes of 5,000 to 9,000 ft. Among these grasses may be mentioned *Alopecurus geniculatus, Echinochloa crusgalli, Festuca rubra, Hemarthria compressa, Lolium temulentum, Poa angustifolia, Poa sterilis, Roegneria striata, Setaria viridis, Stipa orientalis, Carex notha, Carex nubigena* and *Carex setigera.*

Most of these grasses grow in pasture lands and efforts to control the grazing by educating the people will help in preserving them from extermination and improving their quality.

Kishtwar and Bhadrwah which lie in the interior of mountaineous ranges of Jammu Province also have a number of promising grasses growing in various areas. For example *Arthraxon lanceolatus, Bromus japanicus, Bromus oxodon, Poa sterilis, Polypogon sterilis* and *Carex setigera* grow in these places. If proper protection is afforded to them both their quality and quantity will be improved.

It is fortunate that Jammu and Kashmir State is endowed by nature with a salubrious climate and abundance of natural vegetation. It has, therefore, all the factors necessary to produce healthy and sturdy livestock with good yield of milk provided fodder conditions are improved.

It is also gratifying to note that active steps are being taken in the Five-Year Development Plans to improve the cattle wealth by introducing good breeding stocks from foreign countries. The State has also an important sheep rearing industry for production of wool for home consumption and export. The economical maintenance of good breeds of sheep is ultimately based on natural growing grasses and other vegetable material which they pick up during the course of grazing. It, would, therefore, be in the best interest of the people if efforts in this direction are further strengthened by protection and propagation of grasses which have very good nourishing properties.

The Nutrition Advisory Committee of the Indian Council of Medical Research and the Animal Nutrition Committee of the Indian Council of Agricultural Research have jointly recorded shortage of about 58 per cent of roughage and 80 per cent of concentrates for the whole of the country. Because of the shortage of concentrates in the country it has been considered necessary to explore the possibility of utilising

the various natural resources with a view to substituting a reasonable quota of concentrate proteins by grasses. This will not only make up to some extent the deficiency but will help in cheaper milk production so essential for the people of India.

During the course of analysis of the grasses, it was keenly felt that biological testing should also be carried to confirm the nutritive values obtained from chemical analysis but unfortunately no such facilities were available here. It is hoped to get these results confirmed biologically also when such facilities are available.

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Append'x

Analytical data of the different grasses

S. No.	Botanical names	Locality	Altitude	Protein per cent	Ether extractives per cent
			Ft.		
1	*Agropyron longe-aristatum* Boiss (Wild wheat) (Kashmir to Kumaon at 5,500—13,000 ft. Eastern and Western Tibet 12-7,000 ft.)	Gulmarg	9,000	9·139	2·740
		Uri	4,000	7·737	2·912
2	*Agrostis alba* Linn. Western Himalaya and Western Tibet at 6-11,500 ft. From Kashmir to Kumaon, Sikkim 7,500 ft.. Nilgiris hills	Gulmarg	9,000	10·786	1·754
		Khilanmarg	11,000	8·289	1·929
		Kukarnag	5,000	9·671	2·281
		Ramban	2,000	10·828	2·392
3	*Alopecurus arundinaceus Poir.* Western Himalaya at 8-12,000 ft. From Kashmir to Garhwal	Yarikah	7,000	10·684	1·833
		Poonch	3,500	8·644	1·941
4	*A. geniculatus* Linn.—Temperat and subtropical Himalaya 3-7,000 ft. from Kashmir to Bhutan	Kathua	900	14·322	2·877
		Yarikah	7,000	10·868	2·877
		Lakhanpur	900	16·132	2·010
5	*Amphilophis ischaemum* (L) Nash (Vern. Palwan, Pedwa)	Kukarnag	5,000	7·368	1·833
6	*Andropogon annulatus* Forsk. Syn. *Dicanthium annulatum* Stapf. (Vern. Palmaha, barajergi, janewar) Gunjarat, Khandesh, Konkon, Western Ghats, Deccan, S. H country, North Kanara, throughout the hills and plains of India from Kashmir Westward to Bengal and Southwards	Jammu	1,200	8·105	1·333
		Poonch	3,500	4·740	1·491
7	*Cymbopogon jwarancusa* Schult. (Vern. Jara khus, Khavi, Sandula) Plains of N. W. India, Western Himalayas from Kashmir to Kumaon and Western Tibet, ascending to 8,000 ft. North Canara and Deccan, Ahmedabad	Ramnagar	2,500	6·447	3·895
		Reasi	2,000	6·745	1·699
		Srinagar	5,000	7·729	0·701

I—*contd.*

collected from Jammu and Kashmir

Mineral matter per cent	Crude fibre per cent	Carbo-hydrates per cent	Calcium Oxide (CaO) per cent	Phosphorus Pentoxide (P_2O_5) per cent	Calorific value per 100g	Remarks
8·67	38·556	39·443	0·784	0·668	218·9	
11·52	36·772	39·827	0·731	0·501	216·4	
10·72	31·733	43·383	0·896	0·728	223·4	
14·67	32·667	41·282	0·683	0·480	215·6	
12·00	32·421	42·220	0·920	0·487	228·0	
7·88	31·026	46·453	0·954	0·467	250·6	
11·62	31·719	42·889	0·472	0·783	230·7	Common in Tangmarg and Gulmarg Area
14·84	32·867	40·177	0·839	0·692	212·7	
13·41	30·842	36·821	0·625	1·103	230·4	
14·91	19·467	50·413	0·848	0·617	271·0	
12·78	27·800	40·329	0·512	0·437	243·9	
9·05	33·719	46·730	0·896	0·404	232·8	
10·65	44·806	33·925	0·483	0·698	180·1	It is considered to be a good fodder grass
10·42	38·133	44·305	0·676	0·235	209·6	
11·22	28·140	49·193	0·755	0·350	257·6	Nutritious and aromatic grass. It is relished by cattle especially when young
5·54	36·500	48·549	0·652	0·315	236·4	
11·62	40·100	37·853	1·369	0·628	188·6	

Appendix

Analytical data of the different grasses

S. No.	Botanical names	Locality	Altitude	Protein per cent	Ether extractives per cent
			Ft.		
8	*Cymbopogon nardus* Rendle *Citronella grass.* Throughout the hotter parts of India, wild or cultivated	Udhampur	2,200	4·375	2·316
9	*Bothriochloa pertusa* (Willd), A. camus Syn. *Amphilophis pertusa* Stafp (Vern. Palwan sandhor) Gujrat, Konkon, West Ghats, Deccan, Dharwar, North Konkon, Drier parts of India	Akhnoor	1,000	10·960	1·579
		Uri	4,000	4·605	2·351
10	*Cymbopogon schoenanthus* Spreng (Vern. Reuna, Khawi). Hotter part of India, wild or cultivated from Punjab to Travancore	Udhampur	2,200	3·500	1·543
11	*Apluda mutica* Linn Syn. *Apluda varia* Hack sub-sp. mutica Hack (Vern. Chhari, Bhanjura) U.P., Punjab, throughout India ascending the Himalayas to 8,000 ft.	Jammu	1,200	6·907	2·211
		Poonch	3,500	6·278	1·525
		Mendhar	3,000	4·004	1·872
		Rajouri	3,000	6·094	1·560
		Batote	5,500	13·740	1·560
		Ramban	2,000	9·372	2·704
		Uri	4,000	4·605	2·666
12	*Aristida adscenscionis* Linn (Vern. Barlia, lappa) Kutch, Kathiawar, Gujrat, Khandesh, Dharwar, Deccan, Found throughout the plains and low hillls of India, ascending to 8,000 ft. in Kashmir	Akhnoor	1,000	5·526	1·929
13	*Arthraxon lanceolatus* Roxb Syn. *Arthraxon serrulatus* Hochst Western Himalaya alt. 5000-8000 ft. from Kashmir to Nepal, Punjab, Rajasthan, Bihar Gromandel	Batote	5,500	2·533	1·754
		Mendhar	3,000	5·368	1·283
		Rajouri	3,000	10·464	1·768
		Reasi	2,000	5·342	2·140
		Dachigam	5,000	4·053	2·175

I—(*contd.*)

collected from Jammu and Kashmir—contd

Mineral matter per cent	Crude fibre per cent	Carbo-hydrates per cent	Calcium Oxide (CaO) per cent	Phosphorus Pentoxide (P_2O_5) per cent	Calorific value per 100g.	Remarks
11·54	54·526	36·526	0·436	0·281	184·4	Aromatic grass. Used for distillation of essential oil
19·22	38·421	28·540	0·901	0·379	172·2	It is esteemed as good fodder grass for grazing and stocking
7·30	35·684	49·101	0·565	0·394	235·9	
9·09	41·122	44·306	0·295	0·144	205·1	It is eaten by cattle when young
14·61	38·632	36·190	0·848	0·602	192·2	
9·70	42·200	39·330	0·512	0·456	196·1	
4·64	39·133	49·555	0·489	0·307	221·0	It is considered useless as fodder
12·58	37·067	41·716	0·606	0·375	205·2	
8·90	39·767	35·290	0·536	0·207	210·1	
7·00	34·077	45·771	0·756	0·320	244·9	
9·60	36·967	45·326	0·589	0·247	223·7	
11·60	32·245	47·604	0·755	0·341	229·8	It is grazed by the cattle in its young stage
9·24	26·456	59·071	0·590	0·356	262·2	
8·60	34·433	48·996	0·978	0·342	229·0	
12·22	34·033	39·824	1·211	0·480	217·0	
10·19	40·772	40·199	1·025	0·332	201·4	
10·70	32·701	49·276	0·802	0·293	232·8	

Appendix

Analytical data of the different grasses

S. No.	Botanical names	Locality	Altitude	Protein per cent	Ether extractives per cent
			Ft.		
14	*Arundo donax* Linn. (Vern. Naldura, Nal) Lower Himalaya from Kashmir to Nepal upto 3,500 ft., Punjab to Assam, Naga hills, Circars, Nilgiris and Coorg hills	Dachigam	5,000	10·868	3·754
		Near Banihal pass	9,000	9·464	2·010
15	*Arundinella nepalensis* Trin *Syn. Arundinella brasilienis* (Vern. Tutnalia, namza) U.P., Punjab, throughout the hilly part of India Himalayas upto 7000 ft.	Poonch	3,500	7·018	1·352
		Lakhanpur	900	5·377	1·907
16	Avena fatua Linn	Jammu	1,200	11·328	1·648
		Reasi	2,000	6·263	3·053
		Poonch	3,500	10·208	2·461
17	*A. Sativa* Linn. (Vern. Oats, Jai) cultivated throughout India.	Jammu	1,200	32·618	1·403
18	Brachypodium sylvaticum Beauv	Gulmarg	9,000	8·565	1·087
		Desu	5,000	10·464	2·531
19	*Bromus inermis* Leyss	Srinagar	5,000	13·632	2·666
20	*B. Japonicus* Thunb Syn. *Bromus patulus* Mert and Koch	Jammu	1,200	12·986	1·438
		Batote	5,500	12·012	2·496
21	*B. macrostachya* Desf.	Khri Bhavani	5,000	5·732	1·976
22	*B. Oxyodon* Schrenk	Srinagar	5,000	12·618	2·175
		Mendhar	3,000	8·372	1·976
		Bhadarwah	5,000	11·466	2·115
23	*Calamagrostis littorea* DC	Batote	55,000	3·223	3·790
24	*Capillepedium parviflorum* Stapf. Syn. Andropogon micranthus Kunth.	Suandarbani	1,500	6·188	1·109
		Rajauri	3,000	5·004	1·421

I—(*contd.*)

collected from Jammu and Kashmir

Mineral matter per cent	Crude fibre per cent	Carbo-hydrates per cent	Calcium Oxide (CaO) per cent	Phosphorus Pentoxide (P_2O_5) per cent	Calorific value per 100g.	Remarks
12·25	28·733	43·469	0·613	0·313	251·1	It is not a good fodder
12·85	34·666	40·099	0·699	0·212	216·3	
5·24	41·200	44·555	0·465	0·170	218·4	It is useless as fodder
6·48	40·367	45·261	0·443	0·165	219·7	
12·78	29·929	42·256	0·802	1·257	229·1	
10·91	30·526	47·980	0·613	0·655	244·4	
10·40	32·500	43·059	0·722	0·650	235·2	
13·49	34·947	35·723	0·766	1·053	205·9	It is considered to be an excellent fodder crop
9·95	36·600	43·668	0·518	0·612	218·7	
10·08	32·100	34·848	0·582	0·395	240·0	
27·05	21·368	33·252	1·084	0·948	211·5	
17·98	26·456	39·619	0·843	0·678	223·3	
7·06	24·800	52·505	0·582	0·545	280·5	
7·42	32·690	51·353	0·489	0·340	246·1	
9·33	37·367	37·073	0·636	0·801	218·1	
9·60	31·367	47·340	0·745	0·600	240·6	
7·66	31·233	46·539	0·745	0·242	251·0	
10·91	37·227	44·112	0·513	0·225	223·4	
8·94	34·733	48·088	0·582	0·360	227·1	
12·14	36·300	44·139	0·559	0·437	209·3	

Appendix

Analytical data of the different grasses

S. No.	Botanical names	Locality	Altitude	Protein per cent	Ether extractives per cent
			Ft.		
25	*Chloris incompleta* Roth (Vern. Tekhadia, bansi) Gujarat, Khandesh, Konkon, Deccan, Dharwar	Ramnagar	2,500	6·724	1·543
26	*Chrysopogon aucheri* Stapf.	Kathua	900	2·395	2·456
		Akhnoor	1,000	4·094	1·491
27	*C. gryllus* Trin. Syn. *Andropogon Gryllus* Linn (Vern. Kus, Salum) From Kashmir to Sikkim, Khasia hills and Kanara	Yarikah	7,000	8·361	2·073
		Dachigam	5,000	4·237	1·790
		Sunderbani	1,500	4·732	1·109
28	*C. montanus* trin Syn. *Andropogon monticola* Schult. (Vern. (Goria chickua) Throughout India especially in hilly tracts from N. W. Himalayas to S. W. ascending to 6,000 ft.	Ramnagar	2,500	6·079	1·824
29	*Cynodon dactylon* Pers. (Vern. Dub, khabbal) Cosmopolitan	Srinagar	5,000	11·083	1·889
		Jammu	1,200	3·828	1·144
30	*Dactylis glomerata* Linn.	Verinag	6,000	7·680	3·556
		Bhadrawah	5,000	3·184	1·699
		Kishtwar	5,300	5·278	1·248
		Yarikah	7,000	8·462	2·426
31	*Digitaria marginata* Link (Vern. meru) Gujarat, Khandesh, Konkon, West Ghats, Deccan	Srinagar	5,000	12·056	1·964
32	*Echinochloa crus-galli Beauv Syn. Echinochloa glabrescens* Munroex. H. & F. (Vern. sarvank, hama) common throughout the greater part of India	Kukarnag	5,000	6·263	2·069
		Toshmaidan	9,000	3·366	1·421
		Yarikah]	7,000	5·642	1·317

I—*contd.*

collected from Jammu and Kashmir

Mineral matter per cent	Crude fibre per cent	Carbo-hydrates per cent	Calcium Oxide (CaO) per cent	Phosphorus Pentoxide (P_2O_5) per cent	Calorific value per 100g.	Remarks
8·61	39·403	43·013	0·530	0·177	212·8	It is a good fodder grass and eaten when young
11·80	45·122	37·080	0·684	0·463	180·0	
9·90	33·033	50·480	0·745	0·257	231·3	
11·36	29·629	47·259	0·722	0·596	241·1	
9·39	35·227	48·150	0·589	0·617	225·6	This is a good fodder grass
8·36	35·433	49·455	0·606	0·305	226·7	
11·68	33·263	45·671	1·155	0·328	223·4	This is a good fodder grass
13·42	29·184	42·975	0·821	0·628	233·2	
11·14	18·433	64·506	0·559	0·390	283·6	This is one of the most important pasture grass
9·78	32·407	45·196	0·833	0·548	243·5	
6·32	40·767	47·387	0·443	0·200	217·7	
7·06	31·767	53·639	0·606	0·402	246·9	
10·54	31·269	46·349	0·349	0·605	241·0	
14·29	25·267	44·695	0·847	0·881	244·6	
14·77	35·867	39·888	0·896	0·247	203·2	
11·89	35·186	47·015	0·932	0·190	214·3	The grass in young stage is relished by cattle especially by buffaloes
7·65	30·368	54·022	0·349	0·652	250·5	

Appendix

Analytical data of the different grasses

S. No.	Botanical names	Locality	Altitude	Protein per cent	Ether extractives per cent
			Ft.		
33	*Eleusine indica* (L) Gaertn. (Vern. Khurd, Mendhi) Throughout the plains of India	Ramban	2,000	9·464	2·010
		Uri	4,000	10·776	1·614
34	*Eragrostis cynosuroides* Beauv. *Syn. Desmostachya bipinnata* Stapf. (Vern. Darbha, dab, kussa) Kathiawar, Gujrat, Konkon-Deccan	Akhnoor	1,000	6·745	1·456
35	*E. gangetica Steud* Syn. *Eragrostis elegantula* Steud (Vern. Jenkua, khari) Konkon, West Ghats, N. Kanara	Udhampur	2,200	2·855	1·193
36	*E. nigra* Nees	Srinagar	5,000	11·374	1·837
37	*E. pilosa Beauv* (Vern. Galgala, bholoni) Konkon, West Ghats, Deccan, Aharawar	Dachigam	5,000	7·184	1·900
38	*E. Viscosa* Trin Syn. *Eragrostis tenella* Roem & Schult. (Vern. Bhurbur, Chill) From the Ganjetic plains southwards	Kathua	900	7·553	2·877
39	*Erianthus filifolius* Nees	Bhardrawah	5,000	4·822	1·317
40	*E. fulvus* Nees	Jammu	1,200	3·684	1·403
		Kathua	900	5·196	1·352
		Akhnoor	1,000	4·822	1·387
41	*E. hookeri* Hack	Kishtwar	5,300	7·006	2·045
42	*E. ravennae* Beauv (Vern. Dolsar, dolu) U.P., Punjab	Kathua	900	6·447	3·684
		Udhampur	2,200	3·867	1·543
		Poonch	2,500	2·825	1·040
43	*E. versicolor* Nees. ex. Steud	Doda	3,500	3·548	1·664

I—(contd.)

collected from Jammu and Kashmir

Mineral matter per cent	Crude fibre per cent	Carbo-hydrates per cent	Calcium Oxide (CaO) per cent	Phosphorus Pentoxide (P_2O_5) per cent	Calorific value per 100g.	Remarks
12·85	34·666	40·099	0·699	0·212	216·3	A good fodder for all stock. Suitable for pasture for both dry and moist conditions
18·57	19·900	45·832	2·051	1·257	240·9	
12·18	31·467	47·083	0·722	0·347	228·4	It is not relished by the cattle. The fibre is used for making ropes
9·90	41·895	43·559	0·383	0·215	196·3	It is a good fodder grass and can be made into hay
13·54	24·474	46·977	1·328	0·470	249·9	It is a valuable hill grass
12·27	26·947	49·810	1·037	0·852	245·0	It is relished as good fodder
14·77	24·175	49·381	0·678	0·566	253·6	This is used as a fodder in both fresh and dry stage
6·30	38·200	48·532	0·629	0·200	225·2	
8·88	44·351	41·036	0·390	2·256	191·5	
6·02	40·967	45·799	0·349	0·317	216·2	
7·98	38·567	46·448	0·559	0·237	217·5	
9·98	30·133	49·314	1·072	0·450	243·6	
5·14	35·227	48·763	0·442	0·297	253·9	Not of much value as fodder. Valued as an ornamental plant
11·28	38·316	44·589	0·200	0·205	207·7	
6·66	37·367	51·532	0·419	0·157	226·8	
9·60	38·800	45·458	0·745	0·185	211·0	

Analytical data of the different grasses

S. No.	Botanical names	Locality	Altitude	Protein per cent	Ether extractive per cent
			Ft.		
44	*Eulaliopsis binata* (Retz.) *E. Hubbard.* Syn. *Ichaemum angustifolium* Hack Syn. *Pollinidium binatum* (Retz.) C. Hubbard. (Vern. Bhabar, sabai) U.P., Kumaon hills	Ramnagar	2,500	6·125	1·790
		Jammu	1,200	5·434	1·333
		Reasi	2,000	4·467	2·635
		Mendhar	3,000	4·590	1·976
		Sunderbani	1,500	3·730	1·837
		Bhadrawah	5,000	1·546	1·699
		Doda	3,500	4·276	1·803
45	*Festuca modesta* Steud.	Jammu	1,200	14·644	2·035
46	*F. myuros* Linn Syn. *Vulpia myuros* (L) Gmal.	Srinagar	5,000	8·361	2·518
47	*F. rubra* Linn.	Gulmarg	9,000	7·389	3·000
		Yarikah	7,000	9·333	2·592
		Tangmarg	7,000	8·462	1·906
48	*F. valesiaca* Schleich. ex Gaud.	Akhnoor	1,000	6·079	1·543
49	*Glyceria distans* Wahlb Syn. Puccinellia distans (L) Parl.	Srinagar	5,000	12·152	2·518
50	*Heleochloa schoenoides* Host. Punjab, Bundhelkhand, West Himalaya	Jammu	1,200	15·795	1·684
51	*Hemarthria compressa* R. Br. (Vern. Baika). Throughout the hotter parts of India	Jammu	1,200	6·907	1·227
		Yarikah	7,000	12·012	2·149
52	*Heteropogon contortus* Beauv ex R. & S. Syn. *Andropogon contortus* Linn (Vern. sarala, lamb.) Kathiawar, Gujrat, Khandesh, Deccan and Darwar, U.P.	Ramnagar	2,500	3·777	2·456
		Akhnoor	1,000	3·868	2·561
		Doda	3,500	2·548	0·867
		Jammu	1,200	5·342	2·140

I—(contd.)

collected from Jammu and Kashmir

Mineral matter per cent	Crude fibre per cent	Carbo-hydrates per cent	Calcium Oxide (CaC_l) per cent	Phosphorus Pentoxide (P_2O_5) per cent	Calorific value per 100g.	Remarks
6·20	38·351	46·584	0·484	0·466	226·9	
9·18	36·351	46·449	0·932	0·321	219·5	
10·22	34·233	47·759	0·536	0·150	232·6	
13·58	36·467	42·363	0·815	0·209	205·5	A grass of very great economic importance, used in paper making
6·86	35·067	51·692	0·629	0·185	238·2	
9·52	35·867	50·489	0·722	0·157	223·6	
10·56	38·367	44·324	0·513	0·157	210·6	
21·98	20·350	38·880	1·249	0·862	232·3	
9·38	32·592	45·860	0·672	0·617	239·5	
8·24	38·900	41·527	0·498	0·446	222·6	
11·64	31·592	43·507	0·647	0·689	234·6	
6·73	32·205	49·614	0·443	0·640	289·4	
33·62	22·666	34·956	0·802	0·334	178·0	
10·29	23·148	39·385	1·668	0·839	228·8	
17·33	34·701	29·376	0·542	0·572	195·8	
12·86	31·193	46·653	0·743	0·417	225·2	Cattle relish this grass
9·42	28·322	47·133	0·512	0·452	255·9	
7·81	33·158	52·143	0·447	0·209	245·7	
10·32	35·122	47·053	0·825	0·251	227·7	Forms an excellen thay. I st avoided by cattle when the fruit is mature as awned fruit may cause severe sores in the gums and mouths of the cattle
15·04	40·233	40·553	0·629	0·130	180·2	
12·51	40·772	40·199	1·043	0·714	201·3	

Analytical data of the different grasses

S. No.	Botanical names	Locality	Altitude	Protein per cent	Ether extractives per cent
			Ft.		
53	*Hordeum murinum* Huds.	Srinagar	5,000	13·902	2·890
		Kishtwar	5,300	12·740	1·768
54	*Hypogynium foevlatum* (Dels.) Haines-*Eremopogon foveolatus* Stapf (Vern. Ghandel, marvel)	Ramnagar	2,500	4·722	1·720
55	*Imperata cylindrica* (Linn) P. Beauv *Imperata arundinacea* Cyrill (Vern. Siru kusa) Hotter parts of India ascending to the Himalayas 6,500 ft. U. P.	Jammu	1,200	7·184	1·614
		Poonch	3,500	4·648	1·387
56	*Koelcria cristata* Pers	Gulmarg	9,000	8·847	2·593
57	*K. lagopoides Pers Syn. Eleusine brivifolia R.* Br. Coramandal and Karnatik Coast	Srinagar	5,000	10·960	2·140
		Thratay	..	5·914	2·912
58	*Leersia hexandra* SW more or less throughout India	Ningli nursery	5,500	8·289	2·245
		Desu	5,000	8·749	2·666
		Dobgob	5,000	14·828	1·754
59	*Lolium temulentum* Linn.	Yarikah	7,000	8·008	2·080
		Rajouri	3,000	3·640	1·491
		Kathua	900	6·678	2·596
		Yarikah	7,000	7·921	1·684
		Kishtwar	5,300	10·920	1·768
60	*Microstegium ciliatum* A. Camus *Syn. Pollinia ciliata* Trin (Vern. Sau) U. P. Kumoan	Udhampur	2,200	4·927	1·227
61	*M. nudum Syn. Pollinia nuda* Trin.	Uri	4,000	7·092	2·351
62	*Milium effusum* Linn.	Harwan	5,000	17·822	2·947
		Sopur	5,000	7·184	1·800

I—(contd.)

collected from Jammu and Kashmir

Mineral matter per cent	Crude fibre per cent	Carbo-hydrates per cent	Calcium Oxide (CaO) per cent	Phosphorus Pentoxide (P_2O_5) per cent	Calorific value per 100g.	Remarks
13·36	42·592	27·397	0·946	0·913	191·2	
12·30	27·867	43·649	0·769	0·907	241·4	
8·27	31·968	52·588	0·530	0·202	244·7	
11·58	35·403	42·975	0·748	0·496	215·1	The grass is reported to be much relished by cattle and is used for paper making in foreign countries. It is also used for thatching
9·84	35·600	47·340	0·745	0·440	220·4	
8·29	38·518	40·653	0·498	0·601	221·3	
18·93	24·733	41·679	0·872	0·686	229·8	
14·90	33·033	41·847	0·652	0·742	217·2	
16·04	30·600	41·315	0·683	0·828	218·6	The horses and cattle like this grass
16·36	24·033	47·153	0·683	0·356	247·6	
27·81	23·267	30·742	0·919	0·680	198·0	
7·68	26·901	54·242	0·489	0·600	267·7	
7·14	30·767	56·221	0·466	0·275	252·8	
9·28	39·017	41·453	0·472	0·504	215·8	
11·90	35·900	40·436	0·848	1·311	208·5	
11·78	29·100	48·846	0·769	0·817	238·9	
10·40	42·772	39·804	0·507	0·363	189·9	It is not a good fodder
15·54	30·105	43·491	1·037	0·384	223·4	
10·97	29·333	37·432	1·084	0·412	247·5	
12·19	30·200	47·232	0·825	0·569	233·8	

Appendix

Analytical data of the different grasses

S. No.	Botanical names	Locality	Altitude	Protein per cent	Ether extractives per cent
			Ft.		
63	*Muehlenbergia himalayensis* Hack.	Poonch	3,500	3·099	1·525
64	*M. huegelii* Trin.	Kathua	900	8·749	3·543
		Dachigaum	5,000	6·955	1·929
65	*Neyraudia arundinacea* (L) Henr. Syn. *Neyrandia madagascariensis* Hook f. (Vern. *Bichhroo, naltura*). U. P.	Jammu	1,200	3·223	1·087
		Doda	3,500	2·002	1·525
66	*Oplismenus compositus Beauv.* (Vern. Turdia, basahwa) throughout India	Reasi	2,000	10·546	1·438
67	*Panicum antidotale* Retz. (Vern. Ghamor, gharram) Punjab, upper Ganjetic plains	Ramnagar	2,500	9·901	3·508
		Jammu	1,200	13·852	1·790
		Nowshera	1,000	13·376	0·971
		Akhnoor	1,000	3·366	1·871
68	*P. miliaceum* Linn (Vern. Cheena bansiphikar) Cultivated in many parts of India chiefly in Bombay state as also in Western Ghats	Sopore	5,000	3·960	2·833
69	*P. miliare* Lamk (Vern. Kutki) cultivated or naturalised throughout India	Banihal Tunnel	9,000	7·552	1·941
70	*Paspalum Vaginatum* Sw.	Sopar	5,000	11·974	2·000
71	*Pennisetum cenchroides* Rich Syn. *Pennisetum ciliare* (Linn) Link (Vern. Anjan, dhaman) upper Ganjetic plains, Western Peninsula & Deccan	Jammu	1,200	9·026	1·122
		Akhnoor	1,000	4·186	1·387

I—(contd.)

collected from Jammu and Kashmir

Mineral matter per cent	Crude fibre per cent	Carbo-hydrates per cent	Calcium Oxide (CaO) per cent	Phosphorus Pentoxide (P_2O_5) per cent	Calorific value per 100g.	Remarks
9·18	39·067	45·829	0·945	0·355	209·0	
13·85	28·456	43·694	1·061	0·647	241·6	
9·34	32·842	46·630	2·145	0·189	231·7	
4·67	41·964	48·533	0·365	0·158	216·8	It has practically no value as fodder
6·92	43·333	45·612	0·233	0·375	204·1	
16·36	27·719	42·132	1·120	0·685	223·6	It is reported to serve as good fodder but is not relished by cattle and horses. This is used for thatching mostly
10·63	28·772	46·026	0·919	0·244	255·2	According to Stewart the smoke of this grass is used for fumigating wounds and as disinfectant in small-pox
12·42	31·087	39·384	0·896	0·571	229·0	
8·84	37·067	38·740	0·466	0·540	217·2	
7·46	32·267	53·910	0·909	0·217	245·9	
13·71	31·866	46·539	0·660	0·432	227·4	Hot weather crop in the plains and also cultivated in the hills. In the green state it affords good fodder for cattle and horses
16·91	27·421	44·410	1·281	0·485	225·3	Cattle are fond of its straw which is good as fodder
19·73	20·100	44·693	0·825	0·678	244·6	
19·07	26·912	42·634	0·884	0·352	216·7	The grass is reported to be a good fodder for horses and cattle. It is believed to increase milk
7·68	31·400	54·283	0·652	0·412	246·3	

Analytical data of the different grasses

S. No.	Botanical names	Locality	Altitude	Protein per cent	Ether extractives per cent
			Ft.		
72	*P. flaecidum Griseb* (Vern. Manara)	Srinagar	5,000	7·680	2·037
		Poonch	3,500	7·921	1·629
		Dachigaum	5,000	5·986	2·175
		Ramban	2,000	8·736	2·184
		Uri	4,000	7·092	3·474
73	*P. lanatum* Klotch	Dachigaum	5,000	16·947	3·543
		Ramban	2,000	6·278	1·976
74	*P. orientale* Rich (Vern. Birnalsia) Western Himalayas. Punjab Western Peninsula, U.P.	Reasi	2,000	8·932	1·248
		Rajouri	3,000	7·280	1·560
		Thratay	..	6·006	1·560
		Reasi	2,200	8·934	1·158
		Kathua	900	9·026	2·701
75	*Phalaris arundinacea* Linn.	Jammu	1,200	14·460	2·211
		Gulmarg	9,000	12·986	3·017
76	*P. minor* Retz.	Jammu	1,200	12·757	2·421
		Lakhanpur	900	16·406	1·941
		Mendhar	3,000	10·374	1·525
		Poonch	3,500	12·284	2·149
77	*Phleum alpinum* Linn.	Ramban	2,000	8·644	1·837
78	*P. asperum* Jacq. Syn. *Phleum paniculatum* Huds.	Srinagar	5,000	11·374	2·667
79	*Phragmites communis* Trin. (Vern. Narkul) Cosmopolitan in distribution	Jammu	1,200	11·421	2·280
		Rajouri	3,000	12·194	1·733
80	*P. karka* Trin. (Vern. Bansi) U P.	Bhadrwah	5,000	6·642	1·075

I—*contd.*

collected from Jammu and Kashmir

Mineral matter per cent	Crude fibre per cent	Carbo-hydrates per cent	Calcium Oxide (CaO) per cent	Phosphorus Pentoxide (P_2O_5) per cent	Calorific value per 100g. per cent	Remarks
14·84	33·592	40·192	0·909	0·750	209·8	
11·90	35·167	42·152	0·769	0·462	214·9	
9·79	29·859	51·120	0·565	0·505	248·0	
8·88	31·893	47·223	0·674	0·410	243·4	
18·78	24·700	43·896	1·580	0·478	235·2	
9·35	25·367	43·234	0·707	0·852	272·6	
8·32	25·306	57·295	0·373	0·452	272·0	
8·10	32·733	48·073	0·582	0·332	239·2	Not of any account as a fodder grass
9·56	36·933	43·537	0·676	0·454	217·3	
11·60	34·733	44·935	0·676	0·487	217·8	
11·01	38·035	39·749	0·578	0·536	205·1	
8·57	24·666	54·443	0·419	0·175	278·1	
10·25	30·211	41·099	0·790	0·979	242·1	
16·29	31·543	34·854	0·825	0·485	218·5	
17·81	30·035	35·474	0·755	0·748	214·7	
13·62	32·833	33·882	0·606	0·712	208·9	
17·16	30·767	38·676	0·815	0·683	209·9	
15·24	32·733	36·147	0·745	0·702	213·0	
6·53	34·666	47·416	0·465	0·442	240·7	
13·93	30·184	40·224	0·847	0·774	230·3	
10·80	31·053	43·117	0·937	0·392	238·6	It is reported to be a good grass for binding soil. It is a poor fodder. It is reported to be poisonous to cattle in Kumaon
11·80	34·867	37·753	1·258	0·395	215·3	
6·48	41·667	43·625	0·326	0·185	211·7	Tender shoots are greatly relished by horses and are laxative

Appendix

Analytical data of the different grasses

S. No.	Botanical names	Locality	Altitude	Protein per cent	Ether extractives per cent
			Ft.		
81	*Poa angustifolia* Linn. Syn. *Poa pratensis* Linn.	Gulmarg	9,000	7·874	1·637
		Srinagar	5,000	12·541	3·037
		Yarikah	7,000	7·734	3·224
		Tangmarg	7,000	8·190	1·629
82	*P. annua* Linn.	Batote	5,500	12·856	2·773
		Doda	3,500	11·010	2·808
		Kishtwar	5,300	14·738	2·981
		Srinagar	5,000	12·347	3·259
		Dachigaum	5,000	12·376	2·946
83	*P. bulbosa* Linn.	Srinagar	5,000	8·361	3·148
		Yarikah	7,000	6·370	2·080
84	*P. nepalensis* Wall ex Duthie	Yarikah	7,000	14·972	3·184
85	*P. persica* Trin.	Yarikah	7,000	6·188	2·080
86	*P. sterilis* M. Bieb.	Gulmarg	9,000	10·132	2·069
		Dharamsala	1,800	7·916	2·253
		Kishtwar	5,300	5·914	1·352
		Ramban	2,000	6·460	2·392
		Yoshmaidan	9,000	9·746	2·010
87	*Pogonatherum crinitum* Trin.	Rajouri	3,000	3·548	1·768
88	*P. Raniceum* Hack.	Sunderbani	1,500	4·094	1·629

I—*contd.*

collected from Jammu and Kashmir

Mineral matter per cent	Crude fibre per cent	Carbo-hydrates per cent	Calcium Oxide (CaO) per cent	Phosphorus Pentoxide (P_2O_5) per cent	Calorific value per 100g.	Remarks
9·58	37·851	42·113	0·473	0·472	214·6	
12·80	31·073	39·021	0·871	0·657	233·5	
8·29	30·576	49·383	0·373	0·420	257·4	
8·00	35·221	46·075	0·443	0·442	231·7	
16·06	33·000	33·988	0·931	0·392	212·3	
14·10	29·633	41·261	0·698	0·490	234·3	
8·76	26·333	45·798	0·675	0·715	268·9	
15·600	27·962	38·786	1·269	0·777	233·8	
8·77	28·569	46·231	0·443	0·665	213·5	
7·42	26·851	52·991	0·622	0·607	273·7	
5·82	33·453	51·278	0·512	0·487	249·3	
13·67	29·629	36·901	0·672	0·972	236·1	
6·24	35·706	49·122	0·279	0·385	239·9	
9·87	34·633	42·263	0·542	0·491	228·2	
12·64	30·500	45·837	0·559	0·295	235·2	
8·84	35·533	47·457	0·512	0·392	225·6	
8·73	30·264	51·064	0·768	0·322	251·6	
6·59	27·525	52·590	0·932	0·607	267·4	
8·04	38·533	47·048	0·851	0·212	217·3	
12·22	39·133	41·681	1·048	0·195	197·7	

Appendix

Analytical data of the different grasses

S. No.	Botanical names	Locality	Altitude	Protein per cent	Ether extractives per cent
			Ft.		
89	*Polypogon littoralis* Sm.	Jammu	1,200	7·000	1·579
		Bhadrawah	5,000	3·730	1·491
		Doda	3,500	13·468	2·773
		Kishtwar	5,300	11·374	2·357
		Sanderbani	1,500	4·550	1·491
		Srinagar	5,000	17·869	3·017
90	*P. monspeliensis* (L) Desf. (Vern. Chitra, malhar) Common in cultivated grounds in the tropics	Jammu	1,200	11·790	1·298
		Poonch	3,500	9·282	2·461
		Rajouri	3,000	5·368	2·045
91	*Roegneria semicostata* (Nees) Neveski Syn. *Agropyron semicostatum* Nees	Kishtwar	5,300	8·736	2·531
92	*P. striata* (Nees) Neveski	Yarikah	7,000	10·889	2·962
		Gulmarg	9,000	8·749	1·053
		Dachigaum	5,000	5·526	2·982
93	*Rottboellia exaltata* Linn. f. (vern. Bursalis, Bura) Konkon, Deccan, Dharwar & North Kanara	Srinagar	5,000	16·722	3·407
94	*Saccharum arundinaceum* Retz. (Vern. Munj) Bengal, Assam, Frequently cultivated in gardens throughout India	Jammu	1,200	11·605	1·614
95	*S. officinarum* Linn. (Vern. Kamand, ganderi) Cultivated throughout India	Jammu	1,200	4·605	0·979
96	*S. spontaneum* Linn. (Vern. Kans, khus) Throughout India	Jammu	1,200	4·974	1·333
		Banihal pass	9,000	2·912	1·629
97	*Sclerochloa dura* (L) Beauv.	Srinagar	5,000	10·402	1·444

I—*contd.*

collected from Jammu and Kashmir

Mineral matter per cent	Crude fibre per cent	Carbo-hydrates per cent	Calcium Oxide (CaO) per cent	Phosphorus Pentoxide (P_2O_5) per cent	Calorific value per 100g	Remarks
18·42	29·333	42·033	1·191	0·444	210·3	
11·54	33·867	48·466	0·676	0·230	222·2	
17·52	29·667	34·705	1·165	0·702	217·6	
9·88	25·933	49·351	0·515	0·590	264·1	
12·52	37·833	41·427	1·514	0·665	197·3	
19·52	25·700	31·724	1·250	0·920	225·5	
21·87	24·947	38·030	1·167	0·898	210·9	
12·94	28·033	45·962	0·955	0·367	243·1	The grass has little value as fodder
16·52	29·000	45·569	1·211	0·287	222·1	
10·40	29·300	47·761	0·652	0·620	248·7	
10·67	29·333	45·015	0·498	0·633	250·2	
7·87	38·233	43·140	0·424	0·531	217·0	
11·07	35·193	44·260	0·542	0·424	225·9	
14·56	27·03	36·312	1·220	0·742	242·7	The grass is avoided by the cattle on account of hairy sheat leaves
6·21	42·000	37·868	0·483	0·220	212·4	The very coarse leaves are avoided by cattle. Used for construction of houses. Stems are used for making screens and other economical articles
6·97	42·912	43·416	0·460	0·658	200·8	It is source of sugar in India
9·49	36·105	47·218	0·660	0·220	220·7	It is a favourite fodder of buffaloes and is used for that ching for roofs. The local variety has been found to contain hydro cyanic acid
6·44	40·698	47·405	0·629	0·287	215·9	
124·09	24·815	37·630	1·058	0·561	205·1	

Appendix

Analytical data of the different grasses

S. No.	Botanical names	Locality	Altitude	Protein per cent	Ether extractives per cent
			Ft.		
98	*Setaria glauca* Beauv. (Vern. Bandra, sito) Khandeb, Western Ghats, Deccan, U. P. Dharwar	Kukarnag	5,000	6·079	2·351
99	*S. verticillata* (L) Beauv. (Vern. Lapti, chirchira) Kutch, Kathiawar, Gujrat & Konkon	Srinagar	5,000	14·389	1·962
		Ramban	2,000	6·460	2·704
		Banihal	9,000	7·280	1·560
100	*S. viridis* (L) Beauv.	Yarikah	7,000	16·579	2·842
		Khilanmarg	11,000	14·787	2·105
		Srinagar	5,000	14·778	2·000
101	*Sorghum halepense* (L) Pers Syn. *Andropogon halepensis* Brot. (Vern. Baru) Distributed throughout India	Srinagar	5,000	15·458	3·407
		Yarikah	7,000	12·434	2·666
		Jammu	1,200	9·026	1·824
102	*Sporobolus arabicus* Boiss. Punjab & Rajputana	Kukarnag	5,000	5·895	2·633
103	*S. diander* Beauv. (Vern. Chiriya ka-dana) Gujrat, Konkon, West Ghats, Deccan, Dharwar	Akhnoor	1,000	6·447	3·614
104	*S. indicus* R. Br. Western Ghats, Deccan, Kolhapur	Jammu	1,200	11·790	2·912
105	*Stipa Capillata* Linn.	Mendhar	3,000	4·094	1·629
106	*S. jacquemontii* J & S.	Batote	5,500	9·646	2·045
107	*S. orientalis* Trin ex Ledeb	Srinagar	5,000	5·711	4·567

I—*contd.*

collected from Jammu and Kashmir

Mineral matter per cent	Crude fibre per cent	Carbo-hydrates per cent	Calcium Oxide (CaO) per cent	Phosphorus Pentoxide (P_2O_5) per cent	Calorific value per 100g.	Remarks
13·75	31·700	44·530	1·155	0·435	223·5	The grass is liked by the cattle and is considered a good green fodder
19·06	26·926	35·541	0·896	1·226	217·3	It is grazed in young stage of growth by cattle
11·77	28·357	49·766	0·721	0·222	249·2	
13·97	34·250	41·742	0·513	0·685	210·1	
15·85	27·772	40·619	0·754	0·584	254·3	
13·47	26·667	41·896	0·613	0·462	245·6	
18·36	22·867	40·001	1·046	0·948	237·1	
18·53	25·926	34·466	1·294	0·919	230·3	It is reported to cause poisoning
13·28	25·175	44·634	1·320	0·491	252·2	
14·38	30·211	42·349	1·343	0·867	221·9	
9·71	32·633	47·985	0·707	0·437	239·2	
16·13	22·947	49·837	0·590	0·435	257·6	It is a favourite fodder for cattle and horses but the yield is poor
7·85	36·245	39·721	0·961	0·521	232·2	This is valuable fodder grass
10·80	31·700	50·926	0·676	0·175	234·7	
16·22	35·333	35·384	0·815	0·557	198·5	
9·31	21·719	56·533	1·626	0·534	290·0	

Appendix

Analytical data of the different grasses

S. No.	Botanical names	Locality	Altitude	Protein per cent	Ether extractives per cent
			Ft.		
108	*S. sibirica* Lamk.	Uri	4,000	7·737	2·316
		Kukarnag	5,000	7·184	2·701
		Doda	3,500	2·730	1·283
109	*Themeda anathera* Hack. (Vern. Ghatira)	Udhampur	2,200	4·053	2·456
		Poonch	3,500	6·734	1·456
		Ramban	2,000	4·186	2·288
		Banihal	9,000	3·640	1·282
		Banihal pass	9,000	3·184	2·600
		Bandipur	5,000	4·881	1·754
110	*Triticum aestivum* Linn. (Vern. Kanik, gahu) Cultivated throughout India	Akhnoor	1,000	6·539	1·298
		Jammu	1,200	6·171	1·227
111	*Thpha angustata* Chaub & Bory	Srinagar	5,000	16·579	2·526
112	*Bambusa arundinacea* Willd. (Vern. Kalak, munday Bansa)	Akhnoor	1,000	10·316	3·474
113	*B. mutans* wall, ex Munro	Jammu	1,200	10·776	2·561
114	*Dendrocalamus hamiltonii* Nees	Jammu	1,200	15·658	2·351
115	*D. strictus* Nees. (Vern. Kania bans, bans)	Akhnoor	1,000	11·144	2·069
116	*Carex brunnea* Thunb	Batote	5,500	5·249	2·244
117	*C. notha* Kunth	Yarikah	7,000	12·711	2·035
		Batote	5,500	7·552	2·288

I—contd.

collected from Jammu and Kashmir.

Mineral matter per cent	Crude fibre per cent	Carbo-hydrates per cent	Calcium Oxide (CaO) per cent	Phosphorus Pentoxide (P_2O_5) per cent	Calorific value per 100g.	Remarks
7·22	31·087	50·592	0·707	0·341	254·1	
9·22	29·533	49·993	0·920	0·449	253·0	
10·24	39·700	45·500	0·373	0·174	204·4	
9·90	37·543	44·939	0·684	0·425	218·0	This is used as a fodder grass.
9·00	26·400	55·611	0·489	0·310	262·4	
7·65	32·032	52·773	0·721	0·350	248·2	
7·86	37·890	48·823	0·280	0·225	221·3	
5·11	37·266	51·119	0·606	0·115	240·6	
10·08	35·533	46·600	0·966	0·186	221·7	
6·63	33·368	51·417	0·200	0·548	243·5	It is used as fodder and hay.
15·31	36·982	39·078	0·566	0·666	192·0	
12·59	26·912	40·402	0·495	0·496	216·4	
18·61	25·122	41·126	0·743	0·609	237·0	
21·96	32·947	30·976	0·560	0·220	190·0	
16·86	29·298	34·398	0·943	0·492	221·3	
12·08	42·245	31·631	0·554	0·277	189·7	
11·20	36·211	43·760	1·025	0·311	216·2	
8·13	29·367	46·670	0·447	0·640	255·8	
11·96	30·033	46·809	1·118	0·240	238·0	

Appendix—

Analytical data of the different grasses

S. No.	Botanical names	Locality	Altitude	Protein per cent	Ether extractives per cent
			Ft.		
118	*C. nubigena* D. Don	Yarikah	7,000	13·079	3·017
119	*C. setigera* D. Don	Batote	5,500	5·810	1·837
120	*C. vulgaris* Fries	Gulmarg	9,000	13·222	2·481
121	*C. wallichiana* Presc.	Sunderbani	1,500	4·822	1·248
		Doda	3,500	9·282	1·907
122	*Eleocharis plantaginea* R. Br.	Yarikah	7,000	5·007	2·222
123	*E. palustris* R. Br.	Doda	3,500	12·376	1·768
124	*Eriophorum comosum* Wall	Jammu	1,200	4·605	2·385
		Reasi	2,000	4·926	2·184
		Rajouri	3,000	4·732	2·011
		Akhnoor	1,000	4·732	3·016
		Banihal Pass	9,000	9·872	4·329
125	*Kyllinga metizii* Steud. Syn. *Kyllinga squamulata* Vahl.	Jammu	1,200	12·848	2·175

I—contd.

collected from Jammu and Kashmir.

Mineral matter per cent	Crude fibre per cent	Carbo-hydrates per cent	Calcium Oxide (CaO) per cent	Phosphorus Pentoxide (P_2O_5) per cent	Calorific value per 100g.	Remarks
7·79	27·933	47·066	0·683	0·432	267·7	
8·72	29·167	53·321	0·908	0·237	253·0	
12·78	25·444	44·641	0·722	0·710	253·7	
13·28	34·733	44·965	0·722	0·230	210·3	
12·10	42·800	32·703	0·908	0·300	185·1	
11·04	28·148	51·994	0·847	0·742	248·0	
12·86	29·367	42·629	0·815	0·185	235·9	
9·66	31·858	50·811	0·342	0·339	243·1	
11·24	29·000	52·097	0·326	0·227	247·7	
9·08	32·400	50·956	0·606	0·215	240·8	
12·82	23·067	55·582	0·536	0·247	268·4	
9·23	29·917	45·874	0·466	0·312	261·9	
17·26	28·842	36·345	1·603	0·927	216·3	

REVIEW

PROCEEDINGS OF THE SECOND CONFERENCE OF SUGARCANE RESEARCH AND DEVELOPMENT WORKERS, INDIA, 1954. PART II—PAPERS PRESENTED.

Published by

The Indian Central Sugarcane Committee, New Delhi. (1955), pp. 876
Price Rs. 24/-

THE Second Biennial Conference of Sugarcane Research and Development Workers in India, was held at Jullundur in February 1954. Many well-known scientists and development workers connected with sugarcane research and extension programmes attended the conference. A large number of papers were presented at the conference and discussed. These papers have been collected together in the present publication.

The conference was divided into several sections dealing with Sugarcane Breeding and Botany, Sugarcane Entomology, Sugarcane Pathology, Sugarcane Agronomy and Physiology, Sugarcane Development and Sugarcane Chemistry and Soil. The papers presented to the conference have been classified under these heads. Thus there are 19 papers in the section of Sugarcane Breeding and Botany, 18 in Sugarcane Entomology, 10 in Sugarcane Pathology, 62 in Agronomy and Pathology, 11 in Sugarcane Development and 22 in Sugarcane Chemistry and Soil Science. It is, therefore, apparent that no important aspect of sugarcane research and development has been left out. Altogether this is a comprehensive publication on sugarcane in which problems connected with most of the major fields of study have been covered. All these papers have been written by active research workers experts, and they all stimulate thought or elaborate or add to the existing knowledge of the problems dealt with. Such a variety of papers collected together in a single volume has definitely the advantage that results of research on various aspects of sugarcane are available at one place to the convenience of the research workers, administrators and other persons interested in sugarcane problems. Otherwise, a large number of journals and other publications would have to be consulted in order to find out the particular information which is required. The papers have emanated from different laboratories, or have been written by different research workers or experts ; the style of writing, therefore, varies as should be expected in a volume in which contributions from a large number of authors are included. But this does not in any way adversely affect the usefulness of the book. This is a publication which will certainly be helpful to any one interested in sugarcane. The book runs up to 875 pages and is neatly printed and decently bound. Considering the value and size of the book it appears to be moderately priced. (U.N.C.)

"TRACTORS ON THE FARM AND THEIR CHOICE, USE AND MAINTENANCE"

by H. J. Hine

This is the fifth edition of the book, and the contents have been rendered more up-to-date with regard to tractors and other machinery used in British Agriculture at present.

The book contains 17 chapters and covers selection and maintenance of tractors and power implements.

In first chapter is discussed the working principles of the two and four stroke engines, different methods of starting, fuel injection systems in diesel engines, etc. The cooling and lubrication systems have also been treated in a general manner. The aspect of crank-case dilution in vapourizing oil engines has also been discussed.

In discussing the transmission, steering and brake systems in the 2nd chapter of the book, the author while giving a general treatment of the subject has emphasised some of the disadvantages of the differential gear and the reasons for using the differential lock in preference to the same. The note on the various designs of tracks as used in crawler type tractors, lugs on steel wheeled tractors and tread-bars on rubber wheeled machines is very descriptive and has been written with particular reference to wheel slippage and rolling resistance under various conditions of the soil. The text-figures of the National Institute of Agricultural Engineering (U.K.) at the end of the chapter give useful information on wheeled and crawler type tractors.

The use of different tractor fuels, their comparative heat values, properties and characteristics during ignition and the various fuel filtering arrangements employed in practice have been described under the chapter "Fuels for Tractors".

An interesting chapter has been devoted to illustrate the various factors to be considered in choosing a tractor. Steps involved in the determination of the D.B.H.P., output of the tractor, the draw bar pull, the plough resistance and the fuel consumption have been presented in a precise and clear way. The brief notes on the various organisations associated with the testing of tractors —their objectives and utility ; the use of small horse power tractors and the chart showing the Draw Bar performance of tractors run on diesel, petrol and vapourizing oils is quite informative.

A brief chapter on "Driving the tractor" is useful for those who have to learn to operate and drive a tractor.

The general hints and instructions on the care of tractors during cold and damp seasons is useful for Western countries. A separate chapter has been devoted for the care of pneumatic tyres, their repair and maintenance, inflation of air and water for tubes, etc.

An attempt has been made to describe the hydraulic lift mechanism and the methods of hitching implements to the tractors in the chapter entitled "Implement Work".

There is a brief chapter on overhauling of tractors and the question of service and maintenance of the tractors has been dealt in an instructive manner. The chapter is useful from a practical point of view.

Tracing of the causes of breakdown in tractors has been very systematic. In the chapter entitled "Accessories and conversions" the author mentions the various accessories necessary for the tractor. Methods of converting the petrol engine to a vapourizing oil engine has also been discussed here.

Sufficient space has also been devoted to chapters on safety and comforts of drivers, efficient working of the tractors, storage of fuel, lubrication oil, belt work and transport work of tractors.

This book is useful to farmers, tractor drivers and Agricultural Officers, who have to deal with tractors and machinery. Mathematical calculations and formula have been kept to a minimum and the contents can be understood easily by those who can read and understand the language. (R.V.R.)

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